THE TELEGRAPHIC JOURNAL AND

Electrical Review.

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THE POSTMASTER-GENERAL'S REPORT, 1887-8.

THE thirty-fourth annual report of the Postmaster-General is a document teeming with statistics relating to the several services conducted under the auspices of the Department, but otherwise possessing little interest to the general reader. All branches of the service show that onward progress which it has become customary to look for from this Department of the Government Service. Letters have increased 3·6; post-cards, 4·8; book-packets and circulars, 5·6; news-papers, ·8; and parcels, 11·8 per cent. New post-offices have been opened in 396 places, and some 973 letter-boxes have been added, making a total of 36,750 receptacles for the receipt, &c., of letters, of which 17,587 are post-offices; £84,500 has been expended upon the purchase of sites for post-office buildings during the year, besides which £118,000 has been expended in new post-office buildings and in the maintenance and enlargement of existing offices in England, Wales, and Scotland, together with a sum of about £10,300 for similar purposes in Ireland. The gross revenue for the year, including savings bank business, was £11,064,745; and the estimated expenditure, including expenses incurred by other Departments, £8,213,405, leaving a net revenue of £2,851,340, being an increase of £336,705 on the previous year.

The revenue from telegraphs amounted to £1,992,185; expenditure, £1,991,167; the annual interest on the capital sum of £10,880,571 raised by the Government for the purchase of the telegraphs, amounting to £326,417, not being borne on the Post Office Votes, as we are informed by a foot-note, it would appear that although the earnings of the telegraph service are £1,018 in excess of the expenditure, the Department is not paying a fair interest on its capital expenditure. In accepting this conclusion, however, we must not become oblivious to the fact that the telegraph service has been extended to many of the community who would, had the control of the telegraphs remained purely a commercial undertaking in the hands of commercial companies, enjoyed no such privilege. As time goes on, not doubt the expansion of trade, and its multifarious demands upon rapid communication, will enable the Department to show a more satisfactory balance sheet. One important factor with which the Department has to contend, and which is a growing, and, no doubt, a vigorous competitor, is the telephone companies. The facilities afforded by these agencies cannot but be felt by the telegraph revenue.

The total number of telegraph messages forwarded during the year was 53,403,425, being an increase of 3,159,786 over last year. The reduced rate having been in operation the whole of the preceding year, we are able to obtain a comparison of the results of the two years, so far as Inland messages are concerned. Excluding railway, Press, foreign, and official messages, the figures are as follows:—

1886—7	40,137,173
1887—8	43,012,997
Increase	2,985,796

or 7·45 per cent.

London local messages show an increase of 13·8 per cent. On the day preceding Her Majesty's Jubilee ceremony in London last summer, no less than 30,597 local messages passed through the central station; the total number of messages dealt with on that day in the central office being 124,291. It is stated that the increase of work in London on this occasion—that is, on the approach of the ceremony—amounted to nearly 60 per cent.

The following table gives a comparison of figures for seven years, which brings out in a convenient form the expenditure by this Department, and also the amounts paid by other Departments, on account of the Telegraph Service, and also shows the deficit on each year:—

Year.	Receipts.	Expenditure.		Total.	Annual interest on capital.	Deficit.
		By Telegraph Department charged to Post Office.	By other departments.			
	£	£	£	£	£	£
1881–2	1,654,390	1,365,632	74,866	1,440,498	326,417	112,525
1882–3	1,768,070	1,504,204	79,673	1,583,877	326,417	142,224
1883–4	1,789,223	1,709,644	99,276	1,808,920	326,417	346,114
1884–5	1,784,414	1,731,040	89,724	1,820,764	326,417	362,767
1885–6	1,787,264	1,733,104	99,297	1,832,401	326,417	371,554
1886–7	1,887,160	1,939,764	92,868	2,032,632	326,417	471,889
1887–8	1,992,185	1,928,159	63,008	1,991,167	326,417	325,399

New telegraph offices have been opened at 257 post offices and at 39 railway stations throughout the kingdom, the total number of offices now reaching 6,810. Three additional telephone exchanges have been opened, and the number of subscribers increased by 92. The total number of subscribers to the Departments Exchanges on the 31st of March being 1,370, and the revenue obtained therefrom £26,417—not a very rapid stride for an institution possessing the facilities of a Government department practically protected by a monopoly of the subject.

The underground wire system in and around London, as well as in other populous cities, has been extended. Of the 1,745 lines of wire entering the central station not one is aerial. The employment of copper wire, so highly spoken of in a former report, is, to all intents and purposes, abandoned for the present, owing to the abnormal rise in the price of copper.

The report, as stated, abounds in returns and statements illustrating the growth and advance of the several branches of the department, but it gives no information whatever with respect to engineering improvements effected—or, beyond the announcement of the number of new offices opened, of the facilities accorded to the

general public. That the use of copper wire is to be abandoned until it becomes cheaper, that so many more miles of wire have been laid underground, is all the information vouchsafed to us. Appendix J gives us a number of extracts from the Controller's report for the Savings Bank branch. We presume that certain statistics of that branch of the service upon which the conduct of the telegraph service so entirely depends —the engineering branch—are laid before the Postmaster-General when framing his report. We cannot but think, were extracts from such report appended in a like manner to those referred to above, that they would enhance the value of the report. However satisfactory the figures are it would in no way impair this condition if we were told something about the upholding of the system, the improvements being introduced, and the economies contemplated. We see no need for confining the report, as is now done, to returns and statements of a purely commercial character.

ELECTROLYSIS OF TIN SALTS.

By ALEXANDER WATT.

ALTHOUGH there have been many attempts to introduce electro-tinning as a branch of the electro-plating industry, the art has not yet attained a high state of development, at least in this country. That electro-tinning is susceptible of many useful applications is beyond doubt, but it is also true that no really good electrolyte has yet been discovered which will enable the depositor to pursue the art with the same facility and comparative certainty with which he can generally conduct the deposition of other metals which receive his daily attention, as gold, silver and nickel, for example. Of the several causes which affect the uniform action of the tinning baths ordinarily applied, the most important are :—1. That the anode does not dissolve with sufficient rapidity to keep up the normal strength of the solution, which necessitates the frequent addition of tin salt to the electrolyte ; consequently the liquid is never in such an uniform condition as to ensure regularity of deposit. 2. That the tin solutions usually employed, being constantly under atmospheric influence, are continually undergoing change of condition, and as a consequence are unreliable. These are serious faults in any electrolyte to be employed for commercial purposes on a large scale, and place the operator at a continual disadvantage, since he can never know to a certainty when his bath may require an addition of tin salt, nor the precise quantity necessary to keep the bath at its normal strength.

Many different salts of tin have from time to time been employed for making up baths for the electro-deposition of the metal for practical purposes, but it is doubtful whether the chemical field has been sufficiently explored to render improvement improbable. With this impression, I carried out a long series of experiments, the results of which will, it is hoped, prove useful to those who may desire to know the behaviour of other salts of tin than such as are usually employed for the deposition of the metal, while it is possible that the results I am about to describe may suggest further modifications in the minds of others, and thus tend to the ultimate development of a really good tinning bath, free from the defects to which attention has been called. In conducting the following experiments the Daniell battery was employed, and in most instances the current from a single cell, or about ·669 ampère, was found sufficient for the deposition of the metal from most of the electrolytes employed. The anode consisted of a stout plate of tin, about 3 inches square, and the receiving plates were generally strips of sheet brass 3 inches long and 1 inch wide, to each of which a length of copper wire was soldered. Before commencing the various trials, a quantity of the hydrates of protoxide and peroxide of tin was prepared, and after being well washed and drained, the respective oxides were kept in their moist condition for the preparation of tin salts as required.

1. *Protochloride of Tin.*—It is well known that a solution of this salt, when subjected to electrolytic action, deposits metallic tin either in a spongy condition or in the form of crystals, according to the strength or weakness of the electrolyte and the amount of free acid present. When electrolysing a solution of the protochloride it has frequently been noticed, after the electrodes have been immersed in the bath for a few moments, that bright crystals of metallic tin of a feather-like appearance would form upon the surface of the cathode, and eventually spread forwards until they reached the anode, when the current would be short-circuited and the crystals would then drop from the cathode and deposit at the bottom of the vessel. Being anxious to obtain permanent specimens of the beautiful crystals produced from the protochloride solution by electrolysis, I proceeded in the manner described in my former papers on the "Electrolysis of Lead Salts" (ELECTRICAL REVIEW, April 27th, 1888). A solution was first prepared by dissolving 120 grains of fused protochloride of tin in 16 ounces of water, acidulated with half an ounce of hydrochloric acid. This solution was then filtered and afterwards poured into a flat dish, on which was laid a plate of glass about 7 inches by 5 inches. A tin anode, connected to the positive pole of a single Daniell cell, was then immersed in the bath and allowed to rest on one end of the glass plate ; a narrow strip of sheet brass, slightly curved at its lower end, and with copper wire attached, was used as a cathode, and this being connected to the negative electrode of the battery was next placed upright on the opposite end of the glass plate, when in less than half a minute small fern-like crystals began to form at each corner of the cathode, and gradually extended, radiating in all directions, but chiefly in the direction of the anode, until in the course of about half an hour they had attained the length of several inches, the crystals lying perfectly flat upon the surface of the glass plate, like seaweed expanded in water, excepting those in immediate contact with the cathode, which accumulated in clusters reaching to the surface of the liquid, which latter covered the plate to the depth of about one-eighth of an inch. In little more than an hour the plate was nearly covered with crystals of most exquisite beauty, but in separate groups, proceeding from the extreme corners of the cathode. It was noticed that as the crystals grew nearer to the anode they extended with greatly increased rapidity ; so much so, indeed, as to create some little astonishment, while this rapidity of formation caused the crystalline deposit to become highly attenuated at the extreme points nearest the anode. When the crystals had approached within $\frac{1}{16}$th of an inch of the anode, that electrode was withdrawn, and the crystals then carefully disconnected from the cathode with the blade of a penknife, and the brass plate then removed from the liquid. The solution was then carefully and slowly poured out of the dish, and the glass plate bearing the crystals then removed and placed in a nearly upright position upon a pad of blotting paper to drain, after which it was replaced in the dish (which had been previously well rinsed) and water slowly poured in until the plate was well covered, the object being to wash away the adherent tin salt. Portions of the washing water were from time to time withdrawn by means of a pipette, and fresh water applied as before, until the crystals were fairly cleansed from the salt of tin. It should be mentioned that the water used in washing the plate produces a white precipitate, which it is necessary to prevent from settling on the surface of the plate, and this can be effected by the method indicated, but the greatest care is necessary to prevent the fragile deposit from becoming disturbed,

in which case it would inevitably float away from the surface of the plate. Instead of pouring off the tin solution when the crystals are obtained, I find it a better plan to gently raise the glass plate at one end with the first finger and thumb of each hand, and finally rest it on one corner until the greater portion of the liquid has drained from it into the dish; it is then placed on a pad of blotting paper as before mentioned. It is important to bear in mind that if the tin salt surrounding the crystals is not removed by washing, the delicate crystals are apt to become partially redissolved, while the salt will also crystallise in drying, and thus destroy the beauty of the result. When the plate has been sufficiently washed, it is gently removed from the dish and drained as before, and may then be put in a warm place or held before the fire until dry. It should next be coated with a thin varnish—ordinary photographic varnish is most suitable—which should be applied by pouring it in the centre of the plate, and allowing it to flow towards each corner, finally tilting the glass to allow the surplus varnish to return to the bottle. Before and after applying the varnish, the plate should be slightly warmed by holding it at a short distance from the fire.

FIG. 1.

Having now protected the tin crystals by a coating of varnish, we may next proceed to obtain reproductions or prints from them in the same way as ordinary

FIG. 2.

photographic pictures are obtained, by treating the glass plate bearing the crystals in all respects as a photographic "negative." The plate being placed in a suitable printing frame, with the crystals upward, a piece of sensitised albumenised paper is laid on the face of the plate, and over this several folds of blotting paper. The shutter of the frame is then adjusted in the usual manner, and the frame exposed to the action of sunlight until all the details of the crystals are fully impressed upon the sensitised paper. The print is then withdrawn, and is afterwards fixed, toned and washed in the usual way, and after being allowed to dry, may be mounted on a suitable card. In the accompanying illustrations several examples are shown of impressions, taken by the photographic method, of tin crystals produced with solutions of the protosalt of tin at various degrees of concentration, and it will be observed how greatly the forms of the crystals are modified by increasing or diminishing the metallic strength of the tin bath, and also by changing the form of the cathode. In fig. 1 the crystals were produced in a solution containing 7½ grains of fused chloride to each ounce of water, moderately acidulated with hydochloric acid, the cathode employed being stout copper wire of about ¼ inch thickness. Fig. 2 represents crystals obtained in the same bath, with a brass cathode about ½ inch

FIG. 3.

wide. In fig. 3 the crystals were obtained in the above solution, with a cathode turned up into a semi-circular form, the corners facing the anode. Having obtained these results, the solution was next strengthened by the

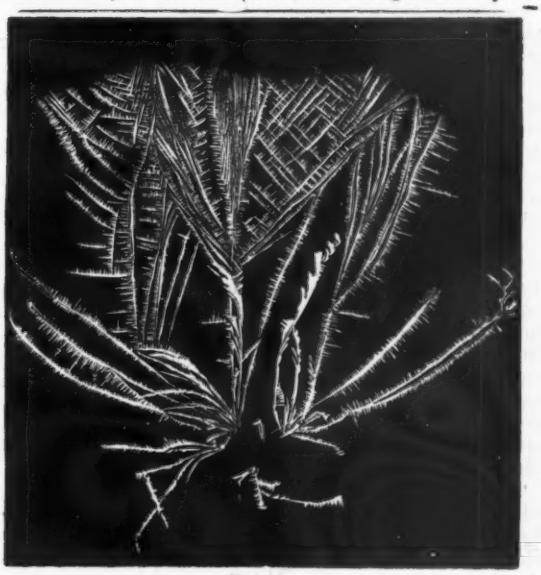


FIG. 4.

addition of more tin salt, about 5 grains to the ounce, without increasing the proportion of hydrochloric acid. Fig. 4 represents the crystals obtained from the solution

thus modified, the curved or semi-circular cathode again being used with the current as before from one Daniell cell. Subsequently the solution was still further strengthened by adding an increased proportion of tin salt, with also a slight addition of hydrochloric acid. The results obtained from this modification are

FIG. 5

shown in figs. 5 and 6, and it will be noticed what a marked difference there is between the latter examples and either of those preceding them. Indeed, from my experiments it became evident that a very slight modi-

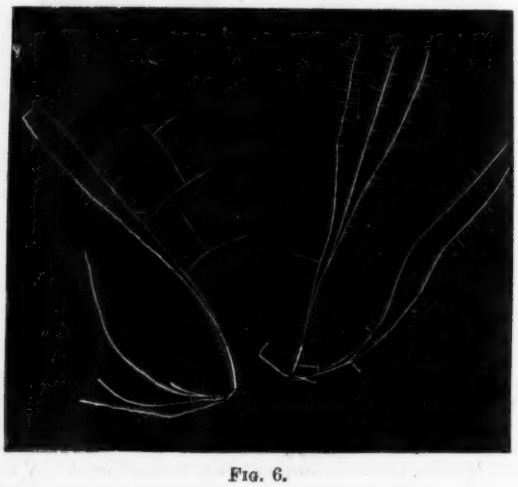


FIG. 6.

fication in the strength of the electrolyte, or of the form of the cathode, was sufficient to cause an immediate change in the character of the crystallisation, without any alteration being made in the strength of the current. When, however, the current was increased by the addition of a second cell, this appeared to have less influence on the form of the crystals than was evidenced by increasing the metallic strength of the solution.

An attempt was next made to obtain a reguline deposit of tin from a solution of the protochloride by trying the liquid at various degrees of dilution, but it was found to be practically impossible to prevent the metal from depositing in a spongy condition unless the cathode was kept constantly in motion while in the bath. In this way, in a very weak solution, the metal could be induced to assume the reguline form, but for any practical purpose of electro-deposition a bath prepared from the protochloride of tin appears to be totally unsuited.

2. *Bichloride of Tin.*—This salt was obtained by dissolving granulated tin in nitro-hydrochloric acid, and the concentrated solution thus obtained was afterwards added to water, in varying proportions, with the object of obtaining, if possible, a reguline deposit of the metal. The first bath was composed of two fluid drachms of the concentrated solution of the bichloride to three ounces of water, and the current from a single Daniell cell was employed. On immersing a brass plate in this solution, and a very small anode surface, a white film of tin was promptly obtained, and continued to retain this appearance for some minutes, but in about a quarter of an hour the film assumed a darkish colour, and the deposit became pulverulent. The solution was next diluted with three more ounces of water and a fresh plate immersed, while the anode surface was also reduced. The deposit, as before, was very prompt, and of a fine white colour, which it sustained for about fifteen minutes, when the film gradually acquired a grey tone, due, as in the former case, to the deposited metal assuming the powdery form, though not in so marked a degree as in the first case. The bath was next again diluted by adding two more ounces of water—making eight ounces in all—and a freshly prepared brass plate put into the solution, the anode surface being still further reduced until the immersed surface was about one-eighth of that of the cathode. The deposit, though slower than in the former cases, was sufficiently rapid for a good coating, while the film was exceedingly white and perfectly reguline, which conditions were maintained for a much longer period than before. Eventually, however, the deposit at the lower part of the cathode assumed a grey colour, and a spongy mass of the reduced metal appeared at each corner of the plate. A gelatinous mass (doubtless stannic acid) also formed in the solution, and floated on its surface in large clots. Further dilutions of the solution were subsequently tried, but it soon became evident that unless the cathode were kept in constant motion, no considerable thickness of tin, in a reguline condition, could be obtained from this solution. It was also found to be difficult to obtain crystals of the metal from solutions of the bichloride. A strip of zinc was immersed in the bichloride solution for some hours, at the end of which period it was found that this metal had deposited the tin in the form of stannic acid, which, being filled with bubbles of gas, floated on the surface of the liquid to the depth of about one inch.

3. *Tartrate of Potassa and Tin.*—A bath was prepared by digesting recently-precipitated stannous oxide in a boiling solution of cream of tartar, for which purpose two ounces of the tartar were dissolved in 16 ounces of boiling water; an excess of the tin oxide was then added, and the whole well stirred and kept hot for about an hour, after which the vessel was set aside to cool, when the clear liquor was decanted for use. With the current from a single Daniell, a white and bright film of tin gradually formed upon a brass cathode, but this assumed a pearly appearance after a few moments. The anode surface was about equal to that of the cathode, and there was no evolution of hydrogen. At the end of about two hours the plate had received a fairly good coating of metal, which was uniformly homogeneous and of good white colour. It was noticed that the anode kept perfectly clean in this solution.

4. *Tartrate of Binoxide of Tin.*—Bichloride of tin solution was precipitated with a solution of sesquicarbonate of ammonia, and the precipitate, after being well washed, was digested in a strong and hot solution of tartaric acid, in which the binoxide freely dissolved, forming a clear solution. The concentrated solution was next diluted with about eight volumes of water, and first tried with the current from a single Daniell, which, however, proved to be too weak, so a second cell was connected in series, when on immersing a clean brass plate an opalescent film of tin, of good colour, and bright in parts, soon formed, but there was a vigorous evolution of gas at both electrodes. The film, though uniform, being in alternate streaks of bright and dull metal, was perfectly reguline, and there was no evidence of loose or spongy particles of metal after half an hour's immersion.

(*To be continued.*)

Our Columns.—Our space is so much occupied with matters relating to the British Association meeting that we are compelled to leave over several articles and letters till next week.

THE BRITISH ASSOCIATION.

(From the Special Correspondent of the "Electrical Review.")

ADDRESS TO THE MATHEMATICAL AND PHYSICAL SECTION.

By PROFESSOR G. F. FITZGERALD, M.A., F.R.S.,
President of the Section.

THE British Association in Bath, and especially we here in Section A, have to deplore a very great loss. We confidently anticipated profit and pleasure from the presence in this chair of one of the leading spirits of English science, Dr. Schuster. We deplore the loss and we deplore the cause of it. It is always sad when want of strength makes the independent dependent, and it is doubly sad when a life's work is thereby delayed; and to selfish humanity it is trebly sad when, as in this case, we ourselves are involved in the loss. And our loss is great. Dr. Schuster has been investigating some very important questions. He has been studying electric discharges in gases, and he has been investigating the probably allied question of the variations of terrestrial magnetism. We anticipated his matured pronouncements upon these subjects, and also the advantage of his very wide general information upon physical questions, and the benefit of his judicial mind while presiding here.

As to myself, his substitute, I cannot express how much gratified I feel at the distinguished honour done me in asking me to preside. It has been one of the ambitions of my life to be worthy of it, and I will do my best to deserve your confidence; man can do no more, and upon such a subject "the less said the soonest mended."

I suppose most former occupants of this chair have looked over the addresses of their predecessors to see what sort of a thing was expected from them. I find that very few had the courage to deliver no address. Most have devoted themselves to broad general questions, such as the relations of mathematics to physics, or more generally deductive to inductive science. On the other hand, several have dealt each with his own speciality. On looking back over these addresses my attention was specially arrested by the first two past presidents of this section, whose bodily presence we cannot have here. They were presidents of Section A in consecutive years. In 1874 Provost Jellett occupied this chair, and in 1875 Professor Balfour Stewart occupied it. Both have gone from us since the last meeting of this Association. Each gave a characteristic address. The Provost, with the clearness and brilliancy that distinguished his great intellect, plunged through the deep and broad questions surrounding the mechanism of the universe, and with impassioned earnestness claimed on behalf of science the right to prosecute its investigations until it attains, if it ever does attain, to a mechanical explanation of all things. This intrepid honesty to carry to their utmost the principles of whose truth he was convinced, the utter abhorrence of the shadow of double dealing with truth, was eminently characteristic of one whom all, but especially we of Trinity College, Dublin, will long miss as a lofty example of the highest intellectual keenness and honesty, and mourn as the truest-hearted friend, full of sympathy and Christian charity. In 1875 Professor Stewart gave us a striking example of the other class of address in a splendid exposition of the subject he did so much to advance, namely, solar physics. He brought together from the two great storehouses of his information and speculation a brilliant store, and displayed them here for the advancement of science. Him, too, all science mourns. Though, from want of personal acquaintance, I am unequal to the task of bringing before you his many abilities and great character, you can each compose a fitting epitaph for this well-known great one of British science. In this connection I am only expressing what we all feel when I say how well timed was the royal bounty recently extended to his widow. At the same time the niggardly recognition of science by the public is a disgrace to the enlightenment of the nineteenth century. What chancellor or general with his tens of thousands has done that for his country and mankind that Faraday, Darwin, and Pasteur have done? The "public" now are but the children of those who murdered Socrates, tolerated the persecution of Galileo, and deserted Columbus.

In a presidential address on the borderlands of the known delivered from this chair the great Clerk Maxwell spoke of as an undecided question whether electro-magnetic phenomena are due to a direct action at a distance or are due to the action of an intervening medium. The year 1888 will be ever memorable as the year in which this great question has been experimentally decided by Hertz in Germany, and, I hope, by others in England. It has been decided in favour of the hypothesis that these actions take place by means of an intervening medium. Although there is nothing new about the question, and although most workers at it have long been practically satisfied that electro-magnetic actions are due to an intervening medium, I have thought it worth while to try and explain to others who may not have considered the problem what the problem is and how it has been solved. A presidential address such as this is not for specialists; it is for the whole section; and I would not have thought of dealing with this subject only that its immediate consequences reach to all the bounds of physical science, and are of interest to all its students.

We are all familiar with this, that when we do not know all about something there are generally a variety of explanations of what we do know. Whether there is anything of which there are in reality a variety of explanations is a deep question which some have connected with the Freedom of the Will, but which I am not concerned with here. A notable example of the possibility of a variety of explanations for us is recorded in connection with an incident said to have occurred in the neighbouring town of Clifton, where a remarkable meteorological phenomenon, as it appeared to an observing scientist, was explained by others as a bull's-eye lantern in the hands of Mr. Pickwick. Another kind of example is the old explanation of water rising in a pump, that "Nature abhors a vacuum," as compared with the modern one. Nowadays, when we know as little about anything, we say, "It is the property of electricity to attract." This is really little or no advance on the old form, and is merely a way of stating that we know a fact but not its explanation. There are plenty of cases still where a variety of explanations is possible. For example, we know of no *experimentum crucis* to decide whether the people I see around me are conscious or are only automata. There are other questions which have existed, but which have been experimentally decided. The most celebrated of these are the questions between the caloric and kinetic theories of heat, and between the emission and undulatory theories of light. The classical experiments by which the case has been decided in favour of the kinetic theory of heat and the undulatory theory of light are some of the most important experiments that have ever been performed. When it was shown that heat disappeared whenever work appeared, and *vice versâ*, and so the caloric hypothesis was disproved; when it was shown that light was propagated more slowly in a dense medium than in a rare, the sciences of light and heat were revolutionised. Not but that most who studied the subject had given their adhesion to the true theory before it was finally decided in general estimation. In fact, Rumford and Davy's experiments on heat, and Young and Fresnell's experiments on light had really decided these questions long before the erroneous views were finally abandoned. I hope that science will not be so slow in accepting the results of experiment in respect of electro-magnetism as it was in the case of light and heat. Rowland's experiment proving an electro-magnetic action between electric charges depending on their absolute and not relative velocities has already proved the existence of a medium relative to which the motion must take place; but the connection is rather metaphysical, and is too indirect to attract general attention. The importance of the striking experiments was that they put the language of the wrong hypothesis out of fashion. Elementary text-books that halted between two opinions, and, after the manner of text-books, leant towards that enunciated in preceding text-books, had all perforce to give prominence to the true theory, and the whole rising generation began their researches from a firm and true standpoint. I anticipate the same results to follow Hertz's experimental demonstration of a medium by which electro-magnetic actions are produced. Text-books which have gradually been invoking lines of force, in some respects to the aid of learners and in others to their bewilderment, will now fearlessly discourse of the stresses in the ether that cause electric and magnetic force. The younger generation will see clearly in electro-magnetic phenomena the working of the all-pervading ether, and this will give them a firm and true standpoint for further advances.

And now I want to spend a short time in explaining to you how the question has been decided. An illustrative example may make the question itself clearer, and so lead you to understand the answer better. In colloquial language we say that balloons, hot air, &c., rise because they are light. In old times this was stated more explicitly, and therefore much more clearly. It was said that they possessed a quality called "levity." "Levity" was opposed to "heaviness." Heaviness made things tend downwards, levity made things tend upwards. It was a sort of action at a distance. At least it would have required such a hypothesis if it had survived until it was known that heaviness was due to the action of the earth. I expect levity would have been attributed to the direct action of heaven. It was comparatively recently in the history of mankind that the rising of hot air, flames, &c., was attributed to the air. Everybody knew that there was air, but it was not supposed that the upward motion of flames was due to it. We now know that this and the rising of balloons are due to the difference of pressure at different levels in the air. In a similar way we have long known that there is an ether, an all-pervading medium, occupying all known space. Its existence is a necessary consequence of the undulatory theory of light. People who think a little, but not much, sometimes ask me, "Why do you believe in the ether? What's the good of it?" I ask them, "What becomes of light for the eight minutes after it has left the sun and before it reaches the earth?" When they consider that they observe how necessary the ether is. If light took no time to come from the sun, there would be no need of the ether. That it is a vibratory phenomenon, that it is affected by matter it acts through—these could be explained by action at a distance very well. The phenomena of interference would, however, require such complicated and curious laws of action at a distance as practically to put such a hypothesis out of court, or else be purely mathematical expressions for wave propagation. In fact, anything except propagation in time is explicable by action at a distance. It is the same in the case of electro-magnetic actions. There were two hypotheses as to the causes of electro-magnetic actions. One attributed electric attraction to a property of a thing called electricity, to attract at a distance, the other attributed it to a pull exerted by means of the ether, somewhat in the way that air pushes

balloons up. We do not know what the structure of the ether is by means of which it can pull, but neither do we know what the structure of a piece of India-rubber is by means of which it can pull, and we might as well ignore the India-rubber, though we know a lot about the laws of its action, because we do not know its structure, as to ignore the ether because we do not know its structure. Anyway, what was wanted was an experiment to decide between the hypothesis of direct action at a distance and of action by means of a medium. At the time that Clerk Maxwell delivered his address no experiment was known that could decide between the two hypotheses. Specific inductive capacity, the action of intervening matter, the delay in telegraphing, the time propagation of electro-magnetic actions by means of conducting material —these were known, but he knew that they could be explained by means of action at a distance, and had been so explained. Waves in a conductor do not necessarily postulate action through a medium such as the ether. When we are dealing with a conductor and a thing called electricity running over its surface we are, of course, postulating a medium on or in the conductor, but not outside it, which is the special point at issue. Clerk Maxwell *believed* that just as the same air that transmits sound is able by differences of pressure—*i.e.*, by means of its energy per unit volume—to move bodies immersed in it, so the same ether that transmits light causes electrified bodies to move by means of its energy per unit volume. He believed this, but there was no experiment known then to decide between this hypothesis and that of direct action at a distance. As I have endeavoured to impress upon you, no *experimentum crucis* between the hypotheses is possible except an experiment proving propagation in time either directly or indirectly by an experiment exhibiting phenomena like those of the interference of light. A theorist may speak of propagation of actions in time without talking of a medium. This is all very well in mathematical formulæ, but, as in the case of light, we must consider what becomes of it after it has left the sun and before it reaches the earth, so every hypothesis assuming action in time really postulates a medium whether we talk about it or not. There are some difficulties surrounding the complete interpretation of some of Hertz's experiments. The conditions are complicated, but I confidently expect that they will lead to a decision on most of the outstanding questions on the theory of electro-magnetic action. However, there is no doubt that he has observed the interference of electro-magnetic waves quite analogous to those of light, and that he has proved that electro-magnetic actions are propagated in air with the velocity of light. By a beautiful device Hertz has produced rapidly alternating currents of such frequency that their wave length is only about two mètres. I may pause for a minute to call your attention to what that means. These waves are propagated three hundred thousand kilometres in a second. If they vibrated three hundred thousand times a second, the waves would be each a kilometre long. This rate of vibration is much higher than the highest audible note, and yet the waves are much too long to be manageable. We want a vibration about a thousand times as fast again with waves about a mètre long. Hertz produced such vibrations, vibrating more than a hundred million times a second. That is, there are as many vibrations in one second as there are seconds—in a day? No, far more. In a week? No, more even than that. The pendulum of a clock ticking seconds would have to vibrate for four months before it would vibrate as often as one of Hertz's vibrators vibrate in one second. And how did he detect the vibrations and their interference? He could not see them; they are much too slow for that; they should go about a million times as fast again to be visible. He could not hear them; they are much too quick for that. If they went a million times more slowly they would be well heard. He made use of the principle of resonance. You all understand how by a succession of well-timed small impulses a large vibration may be set up. It explains many things, from speech to spectrum analysis. It is related that a former Marquis of Waterford used the principle to overturn lamp-posts; his ambition soared above knocker-wrenching. So that it is a principle known to others besides scientific men. Hertz constructed a circuit whose period of vibration for electric currents was the same as that of his generating vibrator, and he was able to see sparks, due to the induced vibration, leaping across a small air space in this resonant circuit. The well-timed electrical impulses broke down the air resistance just as those of my Lord of Waterford broke down the lamp-post. The combination of a vibrating generating circuit with a resonant receiving circuit is one that I spoke of at the meeting of the British Association at Southport as one by which this very question might be studied. At the time I did not see any feasible way of detecting the induced resonance; I did not anticipate that it could produce sparks. By its means, however, Hertz has been able to observe the interference between waves incident on a wall and the reflected waves. He placed his generating vibrator several wave lengths away from a wall, and placed the receiving resonant circuit between the generator and the wall, and in this air space he was able to observe that at some points there were hardly any induced sparks, but at other and greater distances from his generator they reappeared to disappear again in regular succession at equal intervals between his generator and the wall. It is exactly the same phenomenon as what are known as Lloyd's bands in optics, which are due to the interference between a direct and a reflected wave. It follows hence that, just as Young's and Fresnell's reseaches on the "Interference of Light" prove the undulatory theory of optics, so Hertz's experiment proves the ethereal theory of electro-magnetism. It is a splendid result. Henceforth I hope no learner will fail to be impressed with the theory—hypothesis no longer—that electro-magnetic actions are due to a medium pervading all known space, and that it is the same medium as the one by which light is propagated, that non-conductors can, and probably always do, as Prof. Poynting has taught us, transmit electro-magnetic energy. By means of variable currents energy *is* propagated into space with the velocity of light. The rotation of the earth is being slowly stopped by the diurnal rotation of its magnetic poles. This seems a hopeful direction in which to look for an explanation of the secular precession of terrestial magnetism. It is quite different from Edlund's curious hypothesis that free space is a perfect conductor. If this were true, there would be a pair of great antipoles outside the air, and terrestial magnetism would not be much like what it is, and I think the earth would have stopped rotating long ago. With alternating currents we *do* propagate energy through non-conductors. It seems almost as if our future telegraph cables would be pipes. Just as the long sound waves in speaking tubes go round corners, so these electro-magnetic waves go round corners if they are not too sharp. Prof. Lodge will probably have something to tell us on this point in connection with lightning conductors. The silvered glass bars used by surgeons to conduct light are exactly what I am describing. They are a glass, a non-conducting, and therefore transparent, bar surrounded by a conducting, and therefore opaque, silver sheath, and they transmit the rapidly alternating currents we call light. There would not be the same difficulty in utilising the energy of these electro-magnetic waves as in utilising radiant heat. Having all the vibrations of the same period we might utilise Hertz's resonating circuits, and in any case the second law of thermodynamics would not trouble us when we could practically attain to the absolute zero of these, as compared with heat, long period vibrations.

We seem to be approaching a theory as to the structure of the ether. There are difficulties from diffusion in the simple theory that it is a fluid full of motion, a sort of vortex sponge. There were similar difficulties in the wave theory of light owing to wave propagation round corners, and there is as great a difficulty in the jelly theory of the ether arising from the freedom of motion of matter through it. It may be found that there is diffusion or it may be found that there are polarised distributions of fluid kinetic energy which are not unstable when the surfaces are fixed; more than one such is known. Osborne Reynolds has pointed out another, though in my opinion less hopeful, direction in which to look for a theory of the ether. Hard particles are abominations. Perhaps the impenetrability of a vortex would suffice. Oliver Lodge speaks confidently of a sort of chemical union of two opposite kinds of elements forming the ether. The opposite sides of a vortex ring might perchance suit, or may be the ether, after all, is but an atmosphere of some infra-hydrogen element: these two latter hypotheses may both come to the same thing. Anyway we are learning daily what sort of properties the ether must have. It must be the means of propagation of light; it must be the means by which electric and magnetic forces exist; it should explain chemical actions and, if possible, gravity.

On the vortex-sponge theory of the ether there is no real difficulty by reason of complexity why it should not explain chemical actions. In fact, there is every reason to expect that very much more complex actions would take place at distances comparable with the size of the vortices than at the distances at which we study the simple phenomena of electro-magnetism. Indeed, if vortices can make a small piece of a strong elastic solid we can make watches and build steam engines and any amount of complex machinery, so that complexity can be no essential difficulty. Similarly the instantaneous propagation of gravity, if it exists, is not an essential difficulty, for vortices each occupy all space, and they act on one another simultaneously everywhere. The theory that material atoms are simple vortex rings in a perfect liquid otherwise unmoving is insufficient, but with the innumerable possibilities of fluid motion it seems almost impossible but that an explanation of the properties of the universe will be found in this conception. Anything purporting to be an explanation founded on such ideas as "an inherent property of matter to attract," or building up big elastic solids out of little ones, is not of the nature of an ultimate explanation at all; it can only be a temporary stopping place. There are metaphysical grounds, too, for reducing matter to motion and potential to kinetic energy.

These ideas are not new, but it is well to enunciate them from time to time, and a presidential address in Section A is a fitting time. Besides all this it has become the fashion to indulge in quaint cosmical theories and to dilate upon them before learned societies and in learned journals. I would suggest, as one who has been bogged in this quagmire, that a successor in this chair might well devote himself to a review of the cosmical theories propounded within the last few years. The opportunities for piquant criticism would be splendid.

Returning to the sure ground of experimental research let us for a moment contemplate what is betokened by this theory that in electro-magnetic engines we are using as our mechanism the ether, the medium that fills all known space. It was a great step in human progress when man learnt to make material machines, when he used the elasticity of his bow and the rigidity of his arrow to provide food and defeat his enemies. It was a great advance when he learnt to use the chemical action of fire; when he learnt to use water to float his boats and air to drive them; when he used artificial selection to provide himself with food and domestic animals. For 200 years he has made heat his slave to drive his machinery. Fire, water, earth, and air have long been his slaves, but it is only within the last few years that man has won the battle lost by the giants of old, has snatched the thunderbolt from Jove himself and enslaved the all-pervading ether.

ELECTRO-CALORIMETRY.

By WILLIAM STROUD, D.Sc., B.A., and W. W. HALDANE GEE, B.Sc.

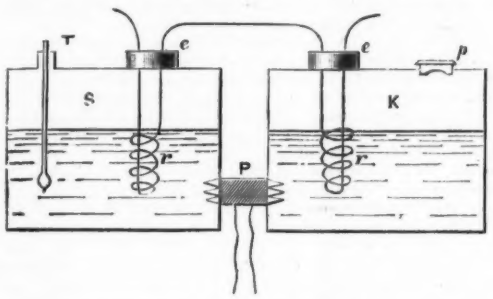
(Section A.—Mathematical and Physical Science.)

Thursday, September 6th, 1888.

[ABSTRACT.]

EXPERIMENTS have been continued, both at Owens College and the Yorkshire College, with the electrical method of measuring the specific heats of liquids described at the B.A. meeting at Manchester. The apparatus now adopted is shown in the fig. The calorimeters, K and S, are employed. They are cylindrical vessels of thin hard rolled sheet brass. In each is a resistance coil, r, r, of insulated platinoid wire fitted in the vessels, e, e, by means of a screw plug, e, e, of ebonite. The calorimeter, S, called the standard, contains a thermometer, T, whilst K is the working vessel, provided with a screw-plug, p, for the admission of a pipette, used in changing the quantity of liquid. Connecting S and K, is a thermopile, P, made of iron and German silver wire. All the fittings are by screws with leather washers or by India-rubber tubing, so that leakage and evaporation is entirely avoided. Instead of the complicated methods formerly adopted for agitating the contents of the calorimeter, the very simple and exceedingly effective one of shaking the vessels themselves has been employed. For this purpose the calorimeters are enclosed within a suitable box, so as to be easily rocked or shaken.

The authors discuss fully the ways of adjusting the rates of rise of temperature when electrically heated, so that these rates may be made as nearly as possible equal. This may be effected by shunting one of the coils or by adjusting the amount of liquids in the calorimeters. The latter method is found the best. For the elimination of small errors methods analogous to those adopted in accurate weighings may be employed. Either a method of reversal



or a method of substitution may be followed. The latter, by far the more preferable method of the two, is conducted as follows:—Equal quantities of water of mass m are at first placed in both calorimeters. After adjustment to equal temperatures the current is passed through the coils, thereby imparting to the calorimeters nearly equal quantities of heat. The difference of temperature, $d\theta$, at the end of the period of heating is observed by the thermopile, and the total rise of temperature, θ, is also noted on the thermometer. Next, the water in K is replaced by the liquid, m, whose specific heat, σ, is desired. This liquid should be approximately equal in thermal value to the water previously in K. A second electrical heating now enables the corresponding quantities, $d\theta^1$, θ^1, to be ascertained. It can then be shown that the formula $\sigma = \frac{m}{m_1}\left(1 + \frac{d\theta}{\theta} - \frac{d\theta^1}{\theta^1}\right)$ is applicable. There is no correction for cooling, for the capacities of the vessels, or for inequality in resistance of the coils. Since $d\theta/\theta + d\theta^1/\theta^1$ may be small, the method is not dependent for its accuracy on thermometers, and hence a much higher degree of accuracy is attainable than is possible by the older methods.

DISCUSSION.

Prof. CARGILL G. KNOTT said the authors of this paper should be commended for bringing forward such an instrument as that which had been described. If what had been said was true, and he had no doubt it was, they had there an instrument for measuring specific heats far in advance of anything previously invented. He would suggest one thing respecting the paper rather as a criticism of form than anything else. It was that that part of it dealing with the thermopiles should form a distinct paper. It was very awkward sometimes that in a paper with a certain name remarks were to be found bearing upon something of quite a different nature, so that, looking to the title only, it was possible for one to miss important remarks which would have been of great interest.

Mr. J. JOLY having offered some observations with regard to the cooling methods of Reynier, which were at once replied to by Prof. Stroud,

The PRESIDENT said some experiments on the measurement of latent heats had been made in his laboratory, but very satisfactory results were not produced. He would suggest to Prof. Stroud that there might be an advantage in using the coils as the two arms of the bridge, and then, if there was any change in temperature, make them two sides of the bolometer. This instrument enabled them to observe the law of cooling at comparatively low temperatures. Mr. Bottomley had been making experiments upon this subject with wires, but by having much larger surfaces, and by shaking occasionally. There was only one point, as it seemed to him, which Prof. Stroud and Mr. Gee had omitted to take notice of. He understood that there was an empty space on the top of the calorimeter. This space might be full of the vapour of the liquid. This might change as the temperature rose, and inasmuch as the latent heat of the vapour was a considerable quantity there would be a certain amount of error due to the amount of liquid vapour, especially as there was so great a difference between the latent heat of water vapour and the latent heat of the vapour of alcohol.

Prof. STROUD said with reference to the application of a bolometer pole as a means of measuring whether there was any difference of temperature or not, and also to the application of the bolometer and the heating coils at the same time, they thought they had made a great discovery in abolishing the thermopile. But he now thought that the bolometer was not comparable with the thermopile for measuring the temperature between the calorimeters. With regard to the President's other point, one knew the volume of the vapour and the temperature at which one was working, and could apply the necessary correction. In ordinary work he believed no account whatever could be taken of latent heat.

ELECTRIC LIGHTING IN AMERICA.

By PROFESSOR GEORGE FORBES, F.R.S.

(Section G.—Mechanical Science.)

Monday, September 10th.

HAVING since the last meeting of the British Association had occasion to pay two visits to the United States, and while there to study very carefully the systems of central station lighting in vogue, and also to compare what was being done there with what was being done here, and being, further, able to compare the state of central station lighting in America as it is at present with the condition it was in four years ago, when this Association visited America, I felt it was a sort of duty I owed to the Association to bring before it some account of what I had seen, believing it would be especially interesting at the present moment, when there are signs of a very great determination on the part of the public in this country to have electric light supplied to them from central stations. At the same time I felt considerable diffidence in bringing before you the facts which have been collected—not in the least because there is any want of facts, but by reason of their number, which renders it difficult to make a proper selection of the points likely to be of interest to the members of this section.

In the first place, it has been often stated, and one cannot help commencing remarks of this kind by repeating, that enormous progress has been made in central station lighting in America. At the moment one lands one is struck by it; and when one lands, upon returning to England, one is equally struck by the dimness of the lighting in our streets. In America there is not a single town with which I am acquainted where you can walk in the streets at night without seeing very many arc lamps. I am not simply speaking of influential towns like New York, Philadelphia, and Boston, but of the most out-of-the-way places in the most distant States, where gas has never penetrated. There electric lighting has fixed its position, and it is being used frequently. Not only has the electric light been adopted in these remote towns, but other developments of electricity have followed. As an illustration of the kind of places to which electricity and electric light have found their way, I may mention that I have a paper here published in a village in Alaska, one of the least developed of the territories of the United States, and the same number of this paper which treats of the introduction of electricity in a scientific manner, treats also of the advisability of passing a law for the expulsion of Indians from the city at nine o'clock every evening.

At the time I was attending the Electric Light Convention at Pittsburgh last February, it was estimated that there were then 300,000 arc lamps lighted from central stations in America. The progress of arc lighting of late years, however, has not been so striking to an Englishman as formerly; the arc light was firmly established when the British Association visited America four years ago. The progress which has struck us all latterly has been the progress in incandescent lighting. At the same time—I am speaking of February of the present year—it was estimated that there were 2½ millions of incandescent lamps in use in the United States; and the rate of manufacture has increased enormously, to my knowledge, since that short time ago. There are four or five manufacturing places in the United States at this moment, each capable of turning out 10,000 incandescent lamps every day, and I have no doubt that the annua production at this moment is to be counted by millions. Of incandescent central stations there are two classes, one of which is the three-wire system, in which a continuous current is supplied to the main conductors over a town and the lamps are connected by branches to the system of positive, negative, and intermediate mains. That is the system which is so largely adopted in all the Edison stations; it was the Edison stations which interested us most in 1884, and they have continued to advance and have developed the three-wire system to a very great extent indeed.

But I feel quite sure that the greatest progress that has been made in central station lighting in America since the Association visited it has been by the work which Mr. Westinghouse has done in that country. One of Mr. Westinghouse's agents in passing through Europe saw the experiments which had been made by

Messrs. Gaulard and Gibbs in this country in the use of alternating currents to distribute the electric light; by means of this system an alternating current of very high tension could be passed along the streets over conductors of very thin diameter and very cheap to construct, and at the consumer's premises this high tension dangerous current could be reduced in tension by means of an induction apparatus called a converter, and passed into the house at a harmless pressure suitable for the ordinary incandescent lamps.

And here I may say that I never fail to take any opportunity which presents itself to me to say what I feel with regard to the energy and determination with which Messrs. Gaulard and Gibbs, in spite of the most adverse criticism which was universally passed upon their first attempts, persevered and continued to improve their invention and eventually proved to the world that it was possible to have a commercial system by means of these converters.

Mr. Westinghouse, on seeing this system, took it up, and the result is that he has established, in the course of a very few years, an enormous business in central station work. It is now a possibility in America—not a possibility merely, but a thing of daily occurrence—for a town to write an order for a central station, which has to be sent out at ten days' notice. They do not order a dynamo, set of conductors, and other apparatus all independently, but complete central stations are being sent out at a steady and uniform rate. In December of last year the manufacturers of incandescent lamps drew out a long list of the number of lamps being used in different parts of the country, and I have abstracted from that list some notes which show that at that time Mr. Westinghouse's alternating current system was supplying 153,285 lamps, occupying 152 distinct plants, and 42 of these had plant for more than 1,000 lamps. At the present moment they have set up 110 central stations with 191,000 lamps.

It has been said that in this country we do not go ahead so much as they do in America, and various reasons have been suggested to account for this. Professor Ayrton's most admirable reason seems to go a long way—namely that there are two definitions of inertia, the English, which is that inertia is a resistance to motion, and the American, that it is a resistance to stopping. But I must say that in electric lighting we certainly have been stopped a great deal by what I might almost call the iniquitous Electric Lighting Act. And I regret extremely, in the interests of the public and of electric lighting generally, that an Act has been passed this year which has not yet put electricity on the same footing as gas. This is a matter for extreme regret to all those who have the ultimate benefit of the electric lighting industry at heart, for that Act will delay the due recognition of the value of electric lighting.

But I must say that I do not think the Electric Lighting Act is the only thing which has delayed our progress, because I see that in electric traction and other developments of electricity also the Americans have gone ahead with great energy, and I certainly do not put it down to want of capacity on the part of our inventors, for I find that the best dynamo machines are all designed originally in England, and the best arc lamps there are are to be found in England; but with inferior machines and lamps in the States, I have noticed that they are determined, as long as they have something which they know will work well, to make it work, and be ready in the meanwhile to take up something else. I think, therefore, that it is not in the inventors that we have to look for goaheadedness, but to men of capital who are technically instructed. I think it is technical instruction among the moneyed classes that has developed electrical engineering so much in America of late years.

I will now try to describe some of the leading features of the Westinghouse central stations which I visited, and perhaps this may be of use in helping us to draw some conclusions as to the lines in which we are to develop electric lighting in our own country. I do not in the least wish to say that the American arrangements are the best. In many points I see objections, and many where I should wish to see improvements; but we have in the system which I am going to describe a thoroughly successful working arrangement, and although we in this country may not adopt all the points of such an arrangement, still I feel that it will be of use to us to realise what is being done on the other side. It is a curious thing, for example, that in America there is no work hardly being done with accumulators. There is an example where we have led the way, as compared with the Americans. I was struck with the fact in 1884, and still more in the present year, that accumulators do not seem to work in the American atmosphere; at any rate, people have been importing numbers of accumulators, and yet they are not recognised as the satisfactory apparatus we have come to regard them as; they are looked upon there as being as uncertain now as they were with us four or five years ago.

The Westinghouse system, then, chiefly depends upon the apparatus, which has been called by the names secondary generator, transformer, or converter; "converter" is the term generally adopted in America. This is simply an induction apparatus with two coils, a primary and a secondary. The primary coil, in contradistinction to the ordinary Ruhmkorff induction coil that we have known so long, is of high resistance, with a large number of turns on the primary and a small number on the secondary, which goes to the lamps. The alternating current produces induction in passing through the primary, which reacts on the secondary, thereby producing a current of low tension going into the houses. The primary coil and the secondary are completely separated, and when properly constructed it is quite impossible that the high tension current can ever reach the secondary circuit, so that the consumers of electricity have nothing to fear from the dangerous current which is distributed from the central station.

A central station contains furnaces and boilers, engines, alternate current dynamos, exciting dynamos, switch boards, testing instruments, repairing shop and stores. The scheme of arrangement of the mechanical and electrical parts is generally the same in every station.

The wires led out from the station are carried generally on poles as feeders to the separate districts. The converters are generally attached to the outside wall of the house to be supplied; but they are often attached to the poles carrying the feeders. They are sometimes placed inside the houses. The secondary wires inside the house, to which the lamps are attached, are laid in the usual manner, and are connected to the secondary poles of the converter. The dynamos are run day and night without cessation; charges are made by contract or by meter.

We hear a good deal here of the impossibility of running machinery day and night without breakdowns, and I cannot help rather endorsing the opinion I heard universally expressed in America—that this fear has been enormously exaggerated in this country. When we see our huge 10,000 to 15,000 horse-power engines crossing the ocean, performing their work for days and weeks without breakdown of any sort, it seems absurd to expect that where we are able to subdivide our power, as in a central station, there should be any serious breakdown in a properly organised system. As a matter of fact I assure you that in America plants which have been run without accumulators have been going on for years and years, and it is a matter of the utmost rarity for an accident to arise of sufficient importance to stop the general lighting of the district. The Edison central station in Pearl Street, New York, which has been running many years, has, I believe, only once broken down, and that was an accidental occurrence due to too much current being turned on on a foggy day, and the experience of other central stations is to the same effect. The general view in America is that there is no danger of a breakdown ever happening in a properly organised station.

It happens that in the department of furnaces and boilers there is much of special interest in many of the Westinghouse stations. This arises from the fact that over a great part of Western Pennsylvania the fuel employed is the natural gas obtained from the wells in that region, and carried in pipes to considerable distances. But this is a feature so peculiar to the district that it requires only a short notice here.

The gas, with its due proportion of air to produce the high temperature of a Bunsen burner, is admitted by pipes with a sufficient number of nozzles into the combustion chamber. Here the burning gas passes over a mass of bricks with ventilating spaces, and thence through the tubes of the boilers. The gas is nearly free from carbon, and the hydrogen, which is paramount, undoubtedly weakens the iron of the boilers; but practice shows that this action does not go far, and the iron acquires a final condition in which it does not deteriorate, but seems capable of indefinite use.

In the best stations the admission of gas and air to the furnaces is regulated by means of a valve controlled by a lever, which in its turn is subject to the pressure of the steam in the boiler. This automatic regulation is very perfect, so that the attendance of one man to the boilers and furnaces of a station with several thousand horse-power is quite sufficient.

As to steam engines there is no need to say much, for I do not think the Americans can teach us anything about making steam engines. But there are some points in connection with the class of steam engine used which I think are of importance. A great deal has been said about the desirability of having central stations furnished with large, powerful, slow-running engines which are economical in the consumption of coal. Practical experience, however, has decided the question for the present exactly in the opposite manner. It is found to be more economical and safer to have a number of dynamos in each station, each driven by a separate engine of high speed, the power being transmitted through a belt and with no countershafting. About the rights of this question there cannot be the slightest doubt. It has been proved over and over again by experience. At first sight it does not seem probable that a number of independent high-speed engines should be more economical or safer than a single large engine, say of the marine type. The explanation lies in the special conditions of central station lighting. Without dwelling upon the great loss of power due to countershafting with the large engine, it is only necessary to observe that the maximum load in a lighting station is many times as great as the average load. Thus, if the single engine be adapted for the maximum load, it is working underloaded during the greater part of the 24 hours. The consumption of steam in proportion to power developed is very high, and the engine is under these circumstances not an economical one. With the independent engines, on the other hand, none of them need at any time be working much under its best load, and when the load increases other engines and dynamos can be switched in, and they are thus always working at or near the most economical conditions.

It has been found from actual practice in electric light work in identical central stations that 20 per cent. more work is required in the case when countershafting is introduced.

It has also been proved, from the experience of numerous central stations, that during a considerable number of hours in the night the load on the engines and dynamos is only one-eighth part of the maximum load.

For these reasons it is found most economical to use with each dynamo an engine whose most economical load is something like

20 per cent. under the maximum load. Waste of steam is far greater with underloading than with overloading.

Another advantage of this system is that there is abundance of time for the inspection of engines and dynamos. The station is easily added to. A breakdown in an engine or dynamo does not stop the working of the station. There is one other factor of safety to which attention must be drawn. One of the most annoying accidents in an electric lighting plant is that due to a short circuit on the mains. In overhead work this often happens by the falling of broken telephone or dead wires upon the mains. In this case a small independent engine is pulled up and no damage is done. With the large engine the dynamo grinds on, and unless the cause of short circuit is burnt up, the dynamo is destroyed, or at any rate the whole of the working is put out of gear.

Now I have a word or two to say about dynamos and converters, the actual apparatus which are used in America. I attribute a great deal of the manufacturing success of American electric lighting plant to this, that they fix upon the types of machine that they are going to make, and then lay down machinery which will enable them to produce those types cheaply, and having thought out the system thoroughly in the beginning, they do not require to make a completely new type of machine for every order that comes in. They are then able to manufacture their machinery cheaply, and in such a way that every part is replaceable.

At this moment I think if I had to choose between two dynamos of which one was a little better than the other in efficiency, but the other of which was manufactured in this way, I should be very much inclined to lean in favour of the one which was made by machinery, and of which all the parts were interchangeable, and of which I could get any one of the parts by return train by telegraphing for it. The convenience of such a machine is obviously great.

I have, for the benefit of those who are electrical engineers and manufacturers, thought it might be of interest to put down some facts in connection with the three types of alternating current dynamo machines made by the Westinghouse Company. There are three types, one for 650 lights, another for 1,300, and another for 2,600. The voltage of all is the same, 1,050. In this country there has been a tendency to use on the primary circuit a higher tension than that, 2,000 volts. In the Westinghouse system they use 1,000 volts at the converters, and 1,050 is developed by the machines. The local pressure is reduced in the same proportion as has been done most generally in Europe, that is to say, in the ratio of 20 to 1. The 1,000 volts in America is reduced down to 50 volts in the lamps, and in this country the 2,000 volts has been reduced to 100 volts at the lamps. And here there is a question opened which must be decided immediately in the central stations which are going to be put down in this country, whether you are going to take the full advantage, as Mr. Westinghouse does, of being able to carry your high-tension current in the mains.

The advantage is that you are able to save copper to a very great extent indeed, whether you use 1,000 or 2,000 volts, and then, as Mr. Westinghouse argues, we are able to use lamps of only 50 volts instead of lamps of 100 volts; that he looks upon as the greatest advantage he has gained by the introduction of the Gaulard and Gibbs system. We all know that the higher the voltage of the lamp the shorter its life, and a 50 volt lamp is a far more perfect thing than a 100 volt lamp. We are greatly troubled by the expense of lamps compared with their life. That is an expensive item in the supply of electricity, and, a 50 volt lamp being far more economical, is it not desirable to follow the American plan and use the lower voltage? I am sure that electrical engineers generally will see that there is a point worthy of their serious consideration in this question.

It may even be said that we are all to go still further and reduce the voltage a great deal more. Of that I am less certain; but there is another point which will occur to electrical engineers, whether it is not desirable to use the lamps which Mr. Bernstein has been perfecting, of very low voltage, placed in series. At present one of the most serious difficulties in introducing electric light for domestic purposes from central stations, is in the cost of wiring houses. Now, if we place our electric lamps all in series, the cost of wiring will be very much diminished, and it becomes a question whether this is not the best arrangement. In that case the primary coils of our converters would be put in series in the same way as they were originally in the Gaulard and Gibbs system. We shall then be doing what they were striving to do when they chose the series arrangement, namely, not by having the two primary terminals inside the house at a difference of potential at 1,000 or 2,000 volts, which would be dangerous, but no two conductors of greater difference of potential than about 50 or 100 volts. If at the same time we use low voltage lamps, we shall get a longer life than even Mr. Westinghouse has obtained. It seem to me that there are grave reasons for considering most seriously the question of arranging all our lamps in series and the primary coils in our converters in series also.

But I am not here to put forward suggestions about what we may probably do in England, but only to tell you what they are doing in America, wishing at the same time to guard myself from saying that they have the best arrangements in every possible point.

The construction of the Westinghouse dynamo is pretty well known in this country, and it is needless to speak of it.

I think we are probably all agreed that the old type of alternating current dynamo, such as the Siemens, has probably seen the end of its days. One of the chief difficulties seems to be that when you have such a large number of coils revolving between the poles you are obliged to make a considerable clearance, and that causes you to use up a geat deal of power in magnetising the field magnets. Mr. Westinghouse makes a very small clearance and in that way uses up only 2 per cent. of the maximum power.

The Westinghouse Company make those types of dynamo, of which the following particulars are of interest:—

Dynamo No.	I.	II.	III.
E.M.F.	1050	1050	1050
Current	35	65	130
Resistance (armature) at 30° C. ...	·76	·37	·15
,, (fields) ,, ,, ,, ...	14·5	7·0	3·6
Weight of wire in armature	17	30	60
,, ,, fields	420	...	...
Total weight	4800	9000	...
No. of lights	650	1300	2600

The No. III. has an armature about 2 feet diameter and 2 feet long. It has 16 poles, and runs at 1,000 revolutions per minute. The armature plates have each 6 large holes for ventilation and lightness. The weight of armature is 2,000 lbs. The insulation is mica and copal varnish, which is found to be infinitely superior to shellac or any other material tried.

The converters used by the Westinghouse Company are of five sizes, called by the numbers I., II., IV., VI. and VIII. The following table gives particulars about them. The size of wire is on the B and S gauge:—

Converter	I.	II.	IV.	VI.	VIII.
No. of lights	5	10	20	30	40
Wire on primary... ...	25	22	19	17	16
,, ,, secondary ...	11	8	8	8	7
Turns on primary ...	900	700	560	480	400
,, ,, secondary ...	45	35	28	24	20
Resistance of primary ...	48	21·9	9·9	7	5
,, ,, secondary...	·04	·043	·0197	·0176	·0107
Weight finished (lbs.) ...	50	60	95	...	160

Thickness of iron plates = ·006 to ·0065 inch.
,, ,, paper insulation = ·0025 inch.
Number of plates in a No. 8 converter = 1350.
The iron used is Welsh Taggard iron.
50° C. rise in temperature is allowed in the converters.

In this country the tendency is to make converters much larger; it has even been suggested that they should be made of thousands of lights. But for ordinary use in houses the Westinghouse system is the simplest, more especially as we find that it is necessary to wire the houses in such a way that they will suit our meters, which at present do not go over a range of from one lamp up to a thousand lamps, nor even up to hundreds of lamps, and if we find that our range is suitable up to 40 lamps it is very desirable to wire the houses in such a way that there are not more than 40 in the circuit of a meter indicating 40. For this reason Mr. Westinghouse has limited his converters in this way.

There are some points well worthy of attention in regard to converters. In the first place, by the use of only 1,000 volts, a far cheaper converter may be made, and thus a great saving may be effected in the plant required for a house. Then, again, there is the rapidity of alternation. In the Westinghouse plant there are 16,000 alternations, 8,000 complete periods, per minute. In this country the tendency is to make the alternations less than that. The quantity of iron you put in your converters depends on the number of alternations; the greater the number of alternations the less iron is required, and you are therefore able to use smaller converters. I do not know whether or not there are objections upon other grounds to a high number of alternations. The only objection that occurs to me is that, while the construction of the dynamo sometimes becomes a little easier, it also takes a little more space.

Mr. Westinghouse asked me to make some tests for him on the efficiency of his converters. It has been supposed that converters have not a high efficiency when working at half load. I may mention that the efficiency varied slightly in the different types, owing to the proportions of iron being greater in some types than in others; but at half-load in some cases we were able to get an efficiency of 95 per cent., which is a splendid result, and I think a greater efficiency than most people have been supposing was to be attained. I do not think that in actual practice there is an average waste of 10 per cent. in the use of converters, when they are properly designed. The formulæ which regulate the construction of converters has been given by me in the *Journal* of the Society of Telegraph-Engineers and Electricians, February, 1888.

I may also say that Mr. Westinghouse has in his lamps 70 per cent. of the power given to the belt by his engine, which is a very good return for converters and alternating dynamos, showing that the new alternating current machines are much superior to the old ones, which gave about 70 per cent. efficiency.

The wiring is nearly all overhead in the States. The wire used is called Simplex wire, and is made by a firm in Boston. It is very carefully prepared, and is, I think, beginning to be known in this country, and gives satisfaction.

For underground work Waring cable, which is lead-covered, is used with complete success. I am informing you now of what is being used, and used successfully, and what may be used successfully by us in this country; but you must not suppose that I hold that these arrangements are the best.

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Now comes a most important point of distribution. Ought the conductors to be massed in one heavy main, with all the dynamos feeding it, or ought the main to be much subdivided, with, perhaps, several to each dynamo? or ought we to take an intermediate arrangement? The experience of the Westinghouse Company leads to the subdivision of mains as far as possible, because a short circuit on any main then endangers only one dynamo.

I have often been asked the question whether alternating dynamos can be worked in parallel. They can, when they are fully loaded down almost to half load, but below that they do not synchronise. Great subdivision of the mains has been found in practice to facilitate largely the working of the central station.

There is one thing that will probably be spoken about in the discussion which will follow my remarks, and that is the high speed of the Westinghouse dynamo. I think there is needless objection to high speed by engineers in this country. If we have a uniform cylinder of iron revolving, I have no objection to any rate of speed so long as I know the shafting will not give way.

I think it would be desirable that some of the gentlemen present should give us their views as to the desirability of using a high or low number of alternations, high or low voltage in the primary, whether 50 volts will be desirable in use, and also as to whether subdivision of mains is desirable, and whether the converters should be supplied have only a limited number of lamps, such as 40 or 50.

I have now attempted to give you a general idea of working central stations in America on the system which has been most fully developed of late years. It is the result of a great amount of careful work, and in the work of the immediate future in England I am sure that English engineers will be benefited by the large practical experience which our trans-Atlantic cousins have collected.

A SIMPLE HYPOTHESIS FOR ELECTRO-MAGNETIC INDUCTION OF INCOMPLETE CIRCUITS; WITH CONSEQUENT EQUATIONS OF ELECTRIC MOTION IN FIXED HOMOGENEOUS OR HETEROGENEOUS SOLID MATTER.

By Sir WILLIAM THOMSON.

(Section A.—Mathematical and Physical Science.)

1. To avoid mathematical formulas till needed for calculation consider three cases of liquid* motion which for brevity I call Primary, Secondary, Tertiary, defined as follows:—Half the velocity in the Secondary agrees numerically and directionally with the magnitude and axis of the molecular spin at the corresponding point of the Primary; or (short, but complete, statement) *half the velocity in the Secondary is the spin in the Primary, and (similarly) half the velocity in the Tertiary is the spin in the Secondary.*

2. In the Secondary and Tertiary the motion is essentially without change of density, and in each of them we naturally, therefore, take an incompressible fluid as the substance. The motion in the Primary we arbitrarily restrict by taking its fluid also as incompressible.

3. Helmholtz first solved the problem—Given the spin in any case of liquid motion, to find the motion. His solution consists in finding the potentials of three ideal distributions of gravitational matter having densities respectively equal to $1/4\,\pi$ of the rectangular components of the given spin; and, regarding for a moment these potentials as rectangular components of velocity in a case of liquid motion, taking the spin in this motion as the velocity in the required motion. Applying this solution to find the velocity in our Secondary from the velocity in our Tertiary, we see that the three velocity components in our Primary are the potentials of three ideal distributions of gravitational matter having their densities respectively equal to $1/4\,\pi$ of the three velocity components of our Tertiary. This proposition is proved in a moment,† in § 5 below, by expressing the velocity components of our Tertiary in terms of those of our Secondary, and those of our Secondary in terms of those of our Primary; and then eliminating the velocity components of Secondary, so as to have those of Tertiary directly in terms of those of Primary.

4. Consider now, in a fixed solid or solids of no magnetic susceptibility, any case of electric motion in which there is no change of electrification, and therefore no incomplete electric circuit, or, which is the same, any case of electric motion in which the distribution of electric current agrees with the distribution of velocity in a case of liquid motion. Let this case, with velocity of liquid numerically equal to $4\,\pi$ times the electric current density, be our Tertiary. The velocity in our corresponding Secondary is then the magnetic force of the electric current system;‡ and the velocity in our Primary is what Maxwell § has well called the "electro-magnetic momentum at any point" of the electric current system; and the rate of decrease per unit of time, of any component of this last velocity at any point, is the corresponding component of electromotive force, due to electro-magnetic induction of the electric current system when it experiences any change. This electromotive force, combined with the electrostatic force, if there is any, constitutes the whole electromotive force at any point of the system. Hence by Ohm's law each component of electric current at any point is equal to the electric conductivity multiplied into the sum of the corresponding component of electrostatic force and the rate of decrease per unit of time of the corresponding component of velocity of liquid in our Primary.

5. To express all this in symbols, let (u_1, v_1, w_1), (u_2, v_2, w_2), and (u_3, v_3, w_3) denote rectangular components of the velocity at time, t, and point (x, y, z) of our primary, secondary and tertiary. We have (§ 1)—

$$u_2 = \frac{d w_1}{d y} - \frac{d v_1}{d z}, \quad v_2 = \frac{d u_1}{d z} - \frac{d w_1}{d x}, \quad w_2 = \frac{d v_1}{d x} - \frac{d u_1}{d y} \qquad (1)$$

$$u_3 = \frac{d w_2}{d y} - \frac{d v_2}{d z}, \quad v_3 = \frac{d u_2}{d z} - \frac{d w_2}{d x}, \quad w_3 = \frac{d v_2}{d x} - \frac{d u_2}{d y} \qquad (2)$$

Eliminating u_2, v_2, w_2 from (2) by (1), we find—

$$u_3 = \frac{d}{d x}\left(\frac{d u_1}{d x} + \frac{d v_1}{d y} + \frac{d w_1}{d z}\right) - \left(\frac{d^2 u_1}{d x^2} + \frac{d^2 u_1}{d y^2} + \frac{d^2 u_1}{d z^2}\right); \text{ \&c.} \qquad (3)$$

But, by our assumption (§ 2) of incompressibility in the primary—

$$\frac{d u_1}{d x} + \frac{d v_1}{d y} + \frac{d w_1}{d z} = 0 \qquad (4)$$

Hence (3) becomes—

$$u_3 = -\nabla^2 u_1, \quad v_3 = -\nabla^2 v_1, \quad w_3 = -\nabla^2 w_1 \qquad (5)$$

where, as in Article xxvii. (November, 1846) of my "Collected Papers" (vol. i.)—

$$\nabla^2 = \frac{d^2}{d x^2} + \frac{d^2}{d y^2} + \frac{d^2}{d z^2} \qquad (6)^*$$

This (5) is the promised proof of § 3.

6. Let now u, v, w denote the components of electric current at (x, y, z) in the electric system of § 4; so that—

$$4\pi u = u_3 = -\nabla^2 u_1; \quad 4\pi v = v_3 = -\nabla^2 v_1; \quad 4\pi w = w_3 = -\nabla^2 w_1 \qquad (7);$$

which, in virtue of (4), give—

$$\frac{d u}{d x} + \frac{d v}{d y} + \frac{d w}{d z} = 0. \qquad (8)$$

Hence the components of electromotive force due to change of current, being, (§ 5)—

$$-\frac{d u_3}{d t}, \quad -\frac{d v_3}{d t}, \quad -\frac{d w_3}{d t},$$

are equal to—

$$4\pi \nabla^{-2}\frac{d u}{d t}, \quad 4\pi \nabla^{-2}\frac{d v}{d t}, \quad 4\pi \nabla^{-2}\frac{d w}{d t}; \qquad (9)$$

and therefore if Ψ denote electrostatic potential, we have, for the equations of the electric motion (§ 5)—

$$u = \frac{1}{\kappa}\left(\nabla^{-2}\frac{d u}{d t} - \frac{d \Psi}{d x}\right); \quad v = \frac{1}{\kappa}\left(\nabla^{-2}\frac{d v}{d t} - \frac{d \Psi}{d y}\right);$$

$$w = \frac{1}{\kappa}\left(\nabla^{-2}\frac{d w}{d t} - \frac{d \Psi}{d z}\right) \qquad (10)$$

where κ denotes $1/4\,\pi$ of the specific resistance.

7. As Ψ is independent of t, according to § 4, we may, conveniently for a moment, put—

$$u + \frac{d \Psi}{\kappa\, d x} = \alpha; \quad v + \frac{d \Psi}{\kappa\, d y} = \beta; \quad w + \frac{d \Psi}{\kappa\, d z} = \gamma \qquad (11)$$

and so find, as equivalents to (9)—

$$\frac{d \alpha}{d t} = \nabla^2(\kappa\alpha); \quad \frac{d \beta}{d t} = \nabla^2(\kappa\beta); \quad \frac{d \gamma}{d t} = \nabla^2(\kappa\gamma); \qquad (12)$$

The interpretation of this elimination of Ψ may be illustrated by considering, for example, a finite portion of *homogeneous* solid conductor, of any shape (a long thin wire with two ends, or a short thick wire, or a solid globe, or a lump of any shape, of copper or other metal homogeneous throughout) with a constant flow of electricity maintained through it by electrodes from a voltaic battery or other source of electric energy, and with proper appliances over its whole boundary, so regulated as to keep any given constant potential at every point of the boundary; while currents are caused to circulate through the interior by changing currents in circuits external to it. There being no *changing electrification* by our supposition of § 4, Ψ can have no contribution

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* I use "liquid" for brevity to signify incompressible fluid.

† From Poisson's well-known elementary theorem, $\Delta^2 V = -4\pi\rho$.

‡ "Electrostatics and Magnetism," § 517 (Postscript) (*c*).

§ "Electricity and Magnetism," §§ 604, 585.

* Maxwell, for quarternionic reasons, takes ∇^2 the negative of mine.

from electrification within our conductor; and therefore, throughout our field—

$$\nabla^2 \Psi = 0 \qquad (13)$$

which, with (8) and (11), gives—

$$\frac{d\alpha}{dx} + \frac{d\beta}{dy} + \frac{d\gamma}{dz} = 0 \qquad (14)$$

Between (12) and (14) we have four equations for three unknown quantities. These, *in the case of homogeneousness* (κ constant), are equivalent to only three, because in this case (14) follows from (12) provided (14) is satisfied initially, and proper surface condition is maintained to prevent any violation of it from supervening. But unless κ is constant throughout our field, the four equations (12) and (14) are mutually inconsistent; from which it follows that our supposition of unchangingness of electrification (§ 4) is not generally true. An interesting and important practical conclusion is, that when currents are induced in any way, in a solid composed of parts having different electric conductivities (pieces of copper and lead, for example, fixed together in metallic contact), there must in general be changing electrification over every interface between these parts. This conclusion was not at first obvious to me; but it ought to be so by anyone approaching the subject with mind undisturbed by mathematical formulas.

8. Being thus warned off heterogeneousness until we come to consider changing electrification and incomplete circuits, let us apply (10) to an infinite homogeneous solid. As (8) holds through all space according to our supposition in § 4, and as κ is constant, (13) must now hold through all space, and therefore $\Psi = 0$, which reduces (10) to—

$$u = \frac{1}{\kappa} \nabla^{-2} \frac{du}{dt}; \quad v = \frac{1}{\kappa} \nabla^{-2} \frac{dv}{dt}; \quad w = \frac{1}{\kappa} \nabla^{-2} \frac{dw}{dt} \qquad (15)$$

These equations express simply the known law of *electro-magnetic* induction. Maxwell's equations (7) of § 783 of his "Electricity and Magnetism," become, in this case—

$$\mu \left(4\pi c + \kappa \frac{d}{dt}\right) \frac{du}{dt} = \nabla^2 u, \text{ \&c.} \qquad (15')$$

which cannot be right, I think, according to any conceivable hypothesis regarding electric conductivity, whether of metals, or stones, or gums, or resin, or wax, or shellac, or gutta-percha, or India-rubber, or glasses, or solid, or liquid electrolytes; being, as seems to me, vitiated for complete circuits, by the curious and ingenious, but, as seems to me, wholly untenable, hypothesis which he introduces in § 610 for incomplete circuits.

(9) The hypothesis which I suggest for incomplete circuits and consequently varying electrification, is simply that the components of the electromotive due to electro-magnetic induction are still $4\pi\nabla^{-2} du/dt$, &c. Thus for the equations of motion we have simply to keep equations (10) unchanged, while not imposing (8), but instead of it taking—

$$\text{"}v\text{"}^2 \left(\frac{du}{dx} + \frac{dv}{dy} + \frac{dw}{dz}\right) = \frac{d}{dt} \nabla^2 \Psi \qquad (16)$$

where "v" denotes the number of electrostatic units in the electro-magnetic unit of electric quantity. This equation expresses that the electrification of which Ψ is the potential increases and diminishes in any place according as electricity flows more out than in, or more in than out. We thus have four equations (10) and (16) for our four unknowns, u, v, w, Ψ; and I find simple and natural solutions with nothing vague, or difficult to understand, or to believe when understood, by their application to practical problems, or to conceivable ideal problems; such as the transmission of ordinary or telephonic signals along submarine telegraph conductors and land lines, electric oscillations in a finite insulated conductor of any form, transference of electricity through an infinite solid, &c. This, however, does not prove my hypothesis. Experiment is required for informing us as to the real electro-magnetic effects of incomplete circuits, and as Helmholtz has remarked, it is not easy to imagine any kind of experiment which could decide between different hypothesis which may occur to anyone trying to evolve out of his inner consciousness a theory of the mutual force and induction between incomplete circuits.

The May Island Electric Light.—Captain Boldt, of the Danish mail steamer *Thyra*, which arrived at Granton on Sunday afternoon from Copenhagen, reports having sighted the May Island light at half past three o'clock in the morning, distant 61 nautical miles. This is the longest recorded distance at which the reflection of this light has been observed. At the time of the observation the atmosphere was exceptionally clear. The highest previous recorded distance was early in February of last year when Captain Rhodin, of the Swedish steamer *Frithiof*, sighted it 46 miles off.

ELECTRIC LIGHT APPLIED TO NIGHT NAVIGATION UPON THE SUEZ CANAL.

By R. PERCY SELLON.

(Section G.—Mechanical Science.—Monday, September 10th.)

I.—The period embracing the concluding years of the last decade, and the first years of the present one, during which a grave commercial crisis made itself felt not only in this country but throughout industrial Europe, witnessed upon the great maritime highway which separates the Eastern and Western hemispheres a rapid increase of traffic and growth of activity.

In 1870, the year following the opening of the Suez Canal, 486 vessels of all kinds availed themselves of the facilities which this new route to the East afforded. Two years subsequently—in 1872—this number had reached over 1,000. In 1878 the number was 1,593, and by the year 1885 it had more than doubled itself, reaching the remarkable total of 3,624 vessels, representing a gross tonnage of 9,000,000 tons.

This active traffic, however, soon gave rise to difficulties of various kinds. Shipowners complained of delays in making the passage of the Canal, delays which became more and more marked as the number of vessels using the canal increased. The channel proper being insufficiently wide (except at the "tying up" stations, which are placed every five miles apart) to admit of vessels passing one another it becomes necessary for any vessel to "tie up" in accordance with signals from the nearest station—these stations being all in telegraphic communication with one another—while any vessel coming from the opposite direction gets past.

This in a canal 87 geographical miles long, and where the speed (except in the open Bitter Lakes) is not allowed to exceed six miles an hour, meant constant delays at "tying up" stations, the delays naturally increasing directly in proportion with the traffic.

Then a further cause of delay lay in the fact that vessels could only proceed by day, anchoring at either entrance to the canal—Port Said or Suez—or "tying up" at the nearest station if in mid-channel, from sunset to sunrise. Thus we find that in 1885 the average time consumed in making the passage of the canal amounted to 43 hours, though it frequently considerably exceeded this.

II.—To meet the difficulty thus presented, the Suez Canal Company set about various improvements; the cutting away of curves in the course, deepening and widening the channel at the "tying up" stations, and finally instituted experiments to determine the practicability of navigation by night by means of the electric light.

The question of the practicability of successful navigation by night in the Suez Canal by means of electric light is not so simple as would at first sight appear. To realise this one must consider that the canal has but an average width of 22 metres (23½ yards) upon the water line, with shelving sides providing for a depth of water of some 8m. 70 to 9 metres (27—30 feet) in the centre and with comparatively sharp curves at various points, as may be seen from the accompanying plan of the canal, fig. 1: and

FIG. 1.

that under such conditions vessels of 400 to 500 feet length, 40 to 50 feet beam, and drawing 25 feet of water, have to navigate the channel, encountering currents of varying force, the action of the wind, and greatly diminished influence of the rudder upon the vessel owing to the slackened speed.

It will be at once seen that under these circumstances it needs but a small deflection between the axis of the vessel and that of the channel to render the vessel liable to run aground. No small amount of judgment and experience thus becomes necessary on the part of the pilot who accompanies each vessel through the Canal.

The problem was, to reproduce by electric light the conditions requisite to enable the pilot to successfully navigate during the night.

These experiments extended over the greater part of two years, with the result that in December of 1885 it was decided to allow vessels of war and those carrying mails, if furnished with electric lights in accordance with regulations laid down by the Canal Company, to proceed by night between Port Said, the Mediterranean entrance to the Canal, and kilometer 54, about one third of the distance along the Canal.

The first vessel to avail itself of this permission was the ss. *Carthage* of the Peninsular and Oriental Steam Navigation Company, in the month of April, 1886, followed shortly afterwards by others, the prescribed passage being made by night by means of the electric light with perfect success.

These and subsequent trials encouraged the Canal Company to extend its authorisation to vessels of all kinds; and, at the same time, by providing beacons and light buoys to guide the vessels in their course by night, to permit of navigation throughout the whole length of the canal.

III.—The following is the text of the regulations on this subject issued by the Suez Canal Company in February, 1887:—

"(i.) From 1st May, 1887, steamers will be allowed to pass through the canal by night, subject to the same conditions as those which hold for navigation by day, and subject to the following further restrictions:—

"(ii.) Steamers intending to pass through the canal by night must satisfy the company's agents at Port Said or Port Tewfik, that they are provided:—(1) Forward, with an electric search light throwing a beam 1,200 metres; this search light must be placed as close as possible to the waterline. (2) With an electric lamp and reflector suspended above the bridge and capable of lighting a circular area of about 200 metres diameter.

"The agents of the company will decide whether the apparatus fulfils the requirements of the regulations, so that vessels provided with them may without inconvenience be authorised to navigate the canal by night.

"(iii.) If a vessel proceeding by night receives the signals to 'tie up,' it must, immediately upon this being effected, extinguish its electric lamps, retaining only the regulation signal lights indicating that it is 'tied up.'"

IV.—Passing now to describe the apparatus designed to fulfil these requirements. This consists essentially of three parts:—

(1) The source of electric power—a steam engine and dynamo-electro generator.

(2) A projector search light fitted upon a platform large enough to accommodate a man to manipulate the light: the whole being attached to the stem of the vessel forward and close to the water's edge.

(3) An automatic electric lamp suspended above the bridge and capable of illuminating a circular area of 200 yards diameter round the vessel.

The accompanying diagrams illustrate these various pieces of apparatus, and also a vessel so fitted traversing the canal.

The engine, fig. 2, is of Brotherhood's 3-cylinder type, fitted direct by means of a flexible coupling to a Victoria dynamo-electric machine, manufactured, as are also the electric lamps and other electrical apparatus, by the Anglo-American Brush Electric Light Corporation, Limited, of London. The engine and dynamo are fitted upon a cast iron bedplate common to both. To ensure reliability of operation, and minimise labour in attendance, the speed of engine and dynamo is reduced to 600 revolutions per minute, at which the latter is capable of yielding an output of 65 volts × 70 ampères or 4,550 watts. This provides for a light in the projector search light equal to 12,000 C.P., and at the same time supplies current for the automatic lamp of 6,000 C.P. over the bridge, when this latter is in use.

The projector search light, fig. 3, fitted upon its platform and fixed during the passage through the canal to the stem of the vessel as near to the water's edge as possible, is used to light the course of the vessel to a distance of 1,200 metres (1,300 yards) ahead.

Actually, the firm of contractors above-mentioned have heard, from recent advices from the Canal, that this light enables the pilot to see clearly as far as 1,600 yards ahead.

The projector proper, which is in many respects similar to the type in use for signalling and search purposes on war vessels, consists of an electric lamp of 12,000 C.P., the light rays from which are concentrated upon a spherical silvered mirror, made by Messrs. Chance, of Birmingham, fixed at the back of the instrument; this mirror reflects the rays, rendering them parallel, and projects them forward in a cylindrical beam; they are then made to pass through a series of plano-cylindrical lenses fitted in the front of the projector, so that the beam emerges in the shape of a fan, flattened horizontally. Fig. 4 illustrates this.

This beam, diverging to an angle of 20°, can by means of suitable adjustments provided for the purpose be directed upon any desired spot. At a distance of 1,200 metres ahead of the vessel the full width of the canal and the banks on either side, composed of the *debris* excavated from the channel, are illuminated as clearly as by day.

An attendant, seated upon the platform, attends to the manipulation of the carbons of the electric lamp, and at the same time regulates the position of the beam of light, elevating, depressing,

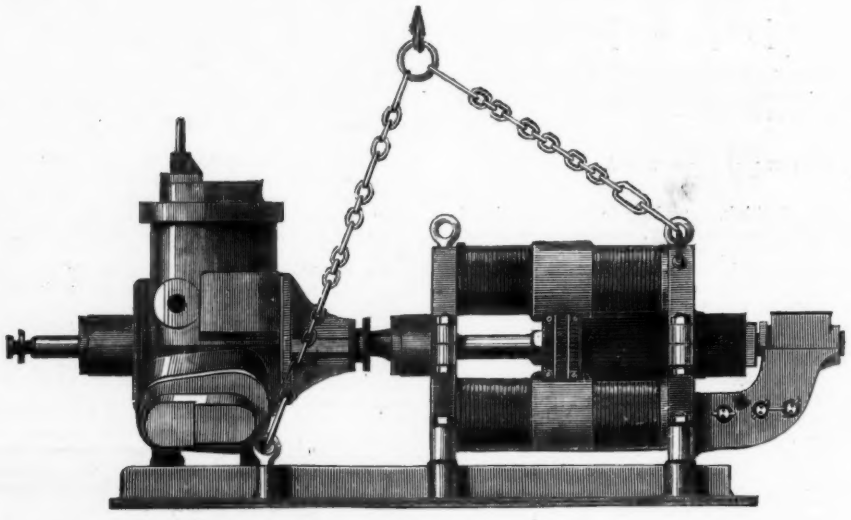


FIG. 2.

or deflecting it on either side in accordance with the orders of the pilot upon the bridge, with whom he is generally in telephonic communication.

The placing of the projector close down to the water's edge, where the light is hidden under the bow of the ship, is a point of essential importance, since any direct rays of light intervening between the pilot and the distant object illuminated by which he steers the vessel, serves to dazzle his eye.

The automatic electric lamp is of 6,000 C.P., enclosed within a lantern fitted with a concave reflector, and arranged to concentrate the light round a circular area of 200 yards. When slung up over the bridge of the vessel the area illuminated includes the whole deck of the vessel and the canal and its banks immediately on either side. This light is only intended for use when passing other vessels "tied up" at the stations, or to provide light around the ship when "tying up" so as to allow another vessel to pass.

V.—A large majority of mail and passenger steamers are now fitted throughout with the incandescence electric light. In fact, electric light has come to be regarded as a *sine qua non* to any first-class passenger vessel.

In such cases the steam engines and dynamo generators already in the ship are usually utilised to supply electricity for the special Suez Canal lamps, which latter may form part of the permanent equipment of the vessel. This is the case with many vessels of the P. and O., the Orient, and the North German Lloyd lines of steamers.

On the other hand, where a vessel which is not already fitted with the electric light desires to avail itself of the permission to traverse the Canal by night, it can hire the necessary plant at either entrance to the Canal.

The *modus operandi* is as follows:—

Several of the prominent coaling firms at Port Said have possessed themselves of a certain number of sets of portable

electric lighting plant for the Suez Canal. These they hold in readiness for vessels to their consignment which may require the light, making an average charge for the use of this, which at the present time amounts to £10 per vessel for the passage through the Canal.

On receiving a given signal from an incoming vessel that electric light is required, a tender is sent out to meet it, having on board the necessary portable plant. Coming alongside, the engine and dynamo are quickly hauled up, dropped on to some convenient spot on deck, and the engine connected with the nearest steam pipe—generally a branch from the system in use for steam winches forward; the automatic lamp slung up over the bridge; the projector floated round and made fast to the stem; temporary conducting wires run from the dynamo generator to

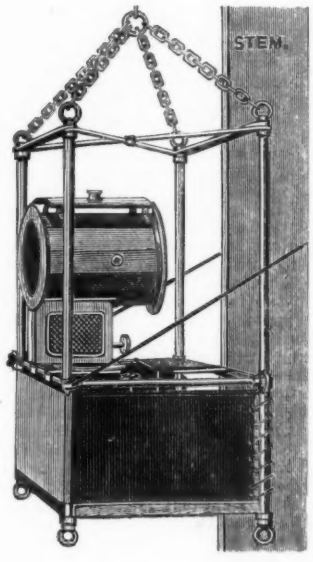


FIG. 3.

the two lamps; and in less than an hour from the time of the tender coming alongside, the ship is ready to make the passage of the Canal by night. On reaching the opposite end of the Canal the electric light plant is disembarked, and the vessel proceeds on her way.

It is with such a portable plant as has just been described, and which the accompanying figures illustrate, that the author was

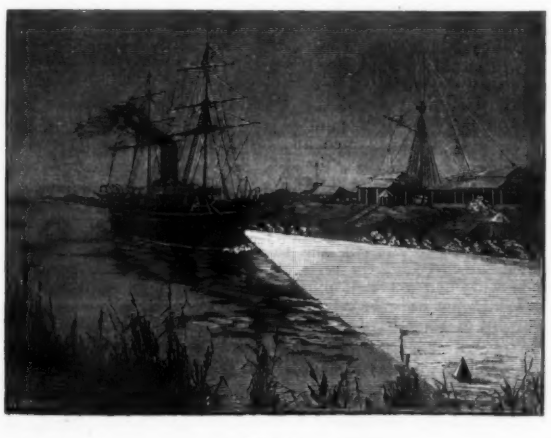


FIG. 4.

engaged in trials upon the Suez Canal in the early part of last year.

VI.—To realise the development which has followed upon the introduction of electric light for the purpose of night navigation, and to appreciate how real has been the benefit flowing therefrom, we have only to examine the following figures, which illustrate the number of vessels which have passed through the Canal in this way at different periods since the first authorisation to use electric light in December, 1885: and which define the percentage of vessels so using the light in comparison with the whole traffic on the Canal:—

PERIOD.	Number of vessels which passed through the Canal by night by means of electric light.	Percentage which these bore to the whole traffic.
From December, 1885, to 1st March, 1887, viz., 15 months	25	·7 per cent.
March, 1887	15	
April "	19	7½ "
May "	19	
June "	25	
July "	27	
August "	35	
September "	45	18 "
October "	49	
November "	62	
December "	75	
January, 1888	85	29 "
March "	111	34½ "
May "	139	43 "

VII.—It remains but to enquire "What are the advantages arising out of the use of electric light on the Canal, which have led to so striking and rapid a development?"

To the Suez Canal Company, on the one hand, it means that the capacity of their Canal has been rapidly, effectively and economically increased by nearly 50 per cent., an increase attained without an army of labourers, without a host of dredgers, without a lapse of years, without interruption to traffic; that while a traffic which reaches 7,000,000 to 8,000,000 tons is now annually attained, an increased traffic, equal to 11,000,000 to 12,000,000 tons per annum can be accommodated, while offering not only equal, but greater, facilities to shipowners making use of the Canal; that in the meantime the Canal Company, relieved of the pressure put upon them from outside, can pursue their works of improvement with greater deliberation and economy.

It is only fair to say, however, that the Suez Canal Company on their side have displayed a ready initiative and far-seeing confidence in the success of the scheme, by putting down a large number of light-buoys to indicate the course by night in the Bitter Lakes, of guiding lights along the banks, and an extensive gas works at Ismailia for supplying the above with gas, at a time when to many an extended adoption of the electric light by shipowners seemed problematical.

To shipowners, on the other hand, it means in the first place a saving of time. I pick up the "Official Gazette" of the Suez Canal Company, published at Paris, for January of this year, and read as follows:—"The *Moskwa*, of the Russian Mercantile Marine, using the electric light, entered the Suez Canal on 12th December at 6.15 p.m., and passed out on the following morning at 8.45 a.m.: total time occupied in the passage 14¼ hours."

In another portion of the same Gazette for the same month, I read as follows:—"The mean time occupied in making the passage of the Canal for all vessels during the month of November last was 36 hours 10 minutes."

Taking as average periods for the passage of the Canal, 18 to 20 hours for all vessels using electric light, and 35 to 40 hours for all vessels not so provided—figures which the Canal company's Official Gazettes and the author's own experience upon the Canal, prove to be in accordance with actual facts—we find that the saving of time resulting from the use of the electric light approaches the 24 hours of a whole day.

What does this saving in time represent?

For vessels carrying cargo exclusively, of an average tonnage of, say 2,500 tons, interest on capital, demurrage, coal consumption, wages, and provision for the crew, represent a sum of £30 to £40 per diem.

For vessels of war, where rapid communication between England and her possessions in the Eastern hemisphere, or the scene of her frequent wars in the Soudan or Africa is by way of the Suez Canal, the saving of 24 hours may entail consequences not easy to calculate.

For mail and passenger boats the results are naturally more marked than in the case of cargo steamers.

An interesting example of the practical value of the electric light is afforded in connection with the transport of mails to the East during the time when the cholera in Italy led to enforced quarantine of all vessels from Italian waters communicating with the shore in Egypt. It has been customary for the mails brought by the Peninsular and Oriental Company from Brindisi to be landed at Alexandria and sent overland to Suez to save the time taken by vessels in the Canal. In order to avoid the delay of quarantine, the mail boats of the Peninsular and Oriental Company proceeded, without unshipping the mails, direct through the Suez Canal by means of the electric light, reaching Suez and transhipping the mails within the same time as that occupied by the overland route in the ordinary way.

The cost per 24 hours of a first-class passenger-carrying vessel, including insurance, demurrage, interest on capital, coal, wages, provision for the crew, and provision for the passengers, cannot be put down at less than £100 to £150.

Taking as an average saving effected by each vessel traversing the Canal by night, a sum of £70 to £80 (a figure which, in view of the proportion of mail and first-class passenger-carrying vessels to the whole traffic on the Canal is well within the mark); and

taking 40 per cent. of the vessels entering the canal as making use of the electric light (a percentage which it will be borne in mind has already been exceeded); we find that for 1,200 vessels having so availed themselves of the electric light, the annual saving to maritime commerce will amount at a minimum valuation to close upon £100,000.

And to this must be added the personal comfort to all concerned derived in escaping some period of the excessive heat experienced upon the Canal by day, the glare from the banks of yellow-white sand, the tedium and monotony of the slow passage through a wide expanse of barren desert.

Without considering to what development this use of the electric light may ultimately attain in an age in which unceasing efforts are being made to economise time and space, it has been attempted, by the foregoing few facts and figures, to illustrate the advance recently made in one adaptation of electricity to the service of man.

The CHAIRMAN (Col. Cunningham, R.E.) said he should guess that the 40 per cent. of the vessels passing through the Suez Canal which used the electric light was composed of the vessels of the largest tonnage, and therefore that the electrically-lighted ships represented much more than 40 per cent. of the tonnage.

Mr. SELLON said no doubt that was the case, but he had no definite figures with regard to tonnage.

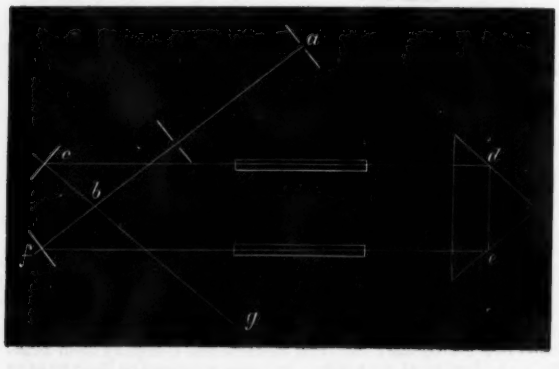
IS THE VELOCITY OF LIGHT IN AN ELECTROLYTIC LIQUID INFLUENCED BY AN ELECTRIC CURRENT IN THE DIRECTION OF PROPAGATION.

By LORD RAYLEIGH.

(Section A.—Mathematical and Physical Science.)

Friday, September 7th.

THE question here proposed has been considered by Roite (Pogg. Ann. 150, p. 164, 1873), and by Lecher (Rep. de Phys. 70, p. 151, 1884).* My experiments were made in ignorance of the work of these observers, and the results would scarcely be worth recording, were it not that the examination seems to have been pushed further than hitherto. It may be well to say at once that the result is negative. The interference fringes were produced by the method of Michelson, as used in his important investigation respecting "The influence of motion of the medium upon the velocity of light."† The incident ray, *a b*, meets a half-silvered surface at *b*, by which part of the light is reflected and part is transmitted. The reflected ray follows the course, *a, b, c, d e, f, b, g*, being in all twice reflected at *b*. The transmitted ray takes the course, *a, b, f, e, d c, b, g*, being twice transmitted at *b*. These rays, having pursued identical paths, are in a condition to form the centre of a system of fringes, however long and far apart may be the courses, *c, d, e f*. There is here nothing to distinguish the ray, *a, b*, from a neighbouring parallel ray. The incident plane *wave front* perpendicular to *a, b* gives rise eventually to two coincident wave fronts perpendicular to *b, g*. With a wave incident in another direction the case is different. The two emergent wave fronts remain indeed necessarily parallel, both having experienced an equal number of reflections (4 and 6). But there will exist in general a relative retardation, of amount (for wave fronts perpendicular to the plane of the diagram), proportional to the deviation from the principal wave front. Hence if the incident light comes in all directions, a telescope at *g*, focussed for infinitely distant objects, reveals a system of influence bands whose direction should be vertical, if the adjustments could be perfectly carried out in the manner intended.



The success of the method does not require the complete symmetry of the diagrams. If the reflections at *d, e*, are effected by a right-angled prism, it is necessary that *c d, f e*, be parallel to one another, but not that they be parallel to the surface, *b*. Supposing all the surfaces to remain vertical in any case, the positions of *b, f*, and the incident ray, *a, b*, may be chosen arbitrarily. If the distance, *d, e*, between the parallel courses is not closely prescribed, *one* adjustment by rotation of the mirror, *c*, will suffice. In my experiments the optical parts were mounted upon a large iron plate, so that the movable pieces, *c, d, e*, could be shifted without loss of level. The incident ray, *a, b*, was defined by a small hole near the paraffin lamp which served as a source of light, and by the centre of moderately large circular aperture perforated in a screen and illuminated when necessary with a candle. The mirror, *c*, was then rotated, until the rays, *c d, f e*, were parallel. This was tested by observing the equality of their mutual distances near the extremities of their course.

If the distance between the parallel rays is prescribed, the adjustment is more troublesome. The line, *f e*, being fixed, sights are laid down defining the desired position of *c d*. These sights, as well as those before referred to defining the incident ray, have now to be brought to apparent superposition as seen by an eye looking along *d c*. For this purpose *two* conditions have to be satisfied by, and two motions must be provided for, the mirror, *c*. One of these should be a movement of rotation, and the other of translation in a direction nearly perpendicular to the plane of the mirror. Thus the mounting may consist of a circular turntable resting upon the iron plate, the curved edge of which is guided by a V cut out of a flat piece of metal and clamped to the plate. In each position of the V the angular motions are easily swept over, and the double adjustment is effected without much difficulty. When the parallelism of the rays is secured, the insertion of the reflecting prism is all that remains. The adjustment of this is best effected with the eye at the observing telescope, which at this stage should be focussed upon the small aperture in the neighbourhood of the flame. By a motion of the prism parallel to its hypothenuse the two images are brought to coincidence,* and then the hands appear, if not at once, when the telescope is accommodated for infinitely distant objects.

The half silvered central plate would be at its best if it reflected lighted of the same intensity as it transmits. I have generally found the reflection on the side next the air more powerful than upon the side next the glass, so that the ideal would require the geometric mean of the two reflections to be equal to that of the two transmissions. A very slight silvering is all that is wanted, such as from its want of coherence and brilliancy would be useless for other purposes; and the bands appear tolerably black, even though the interfering lights are of decidedly unequal intensities. There is, of course, also a reflection from the unsilvered surface of the plate. In my apparatus, owing to a want of parallelism, this image was distinctly separated from the other. The two back reflectors were of flat glass, silvered by the milk-sugar process, and used as specular.

The imperfections of the surfaces disturbed the formation of the bands from full accordance with theory. The definition was usually better when the pencils were limited, as by the screens employed to define the incident ray, than when all obstructions were removed. The final adjustments for the distinctness and desired width of bands were made with the eye at the telescope by shifting the reflecting prism, and occasionally by slight displacements of one of the other reflectors. The tubes enclosing parts of *c d, f e*, and containing the electrolyte (diluted sulphuric acid of nearly maximum conductivity) were closed at the ends by plates of parallel glass. The current entered by lateral attachments, so arranged that liquid (or gas) rising or falling from the platinum electrodes would not at first enter the operative part of the tubes. The diameter of the tubes was about ¾ inch, and the effective length about 11 inches.

It will be sufficient to give the details of one experiment. The two tubes were connected in multiple arc, and, of course, in such a manner that the current travelled in opposite directions. The magnitude of the whole current (say from eight Grove cells) was 1·5 ampères; so that the current *density* in ampères per square c.m. was

$$\frac{\cdot 75}{\pi \times \cdot 38^2 \times 2\cdot 54^2} = \cdot 26.$$

Now one of the interfering rays travelled 22 inches, or 56 centimetres, with the current, and the other ray the same distance against the current. On *reversal* of the current no shift of the bands could be perceived, under conditions where a shift of $\frac{1}{10}$th† of a band must have been evident. Hence we may conclude that a current of the above-mentioned density does not accelerate, or retard, the propagation of light in the ratio of $\frac{1}{10}$th λ to 224 cms. In the liquid we may take $\lambda = 4 \times 10^{-5}$ cm.; and if we reduce the result so as to correspond to density unity, we may say that in dilute sulphuric acid a current of one ampère per square cm. does not alter the velocity of light by one part in 13 millions, or by 15 metres per second.

It would probably be possible to carry the test 10 or 15 times further by the use of much longer tubes and a more powerful

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* Mr. Wilberforce has experimented upon displacement currents in a dielectric (Camb. Phil. Trans., *t.* XIV., p. 170, 1887.)

† *American Journal*, XXXI., p. 377, 1886.

* It should be noticed that if the object were at infinity, or if with the aid of a collimating lens an image of it were thrown to infinity, the two images as seen focussed through the telescope would overlap in any case. For it may be proved that whatever may be the positions of the fine reflecting surfaces, the two emergent rays, corresponding to any incident ray, are necessarily parallel.

† Probably I might say $\frac{1}{20}$th, but it is best to be upon the safe side. When the contact was maintained a slight shift was observed, but in a direction independent of that of the current.

battery: but there seems to be no sufficient encouragement at present to make the attempt. The case would, of course, be very different were anyone to show by *a priori* argument a reason for expecting an effect of this order of magnitude.

ON RECENT DEVELOPMENTS OF THE COWLES' ALUMINIUM PROCESS.

By R. E. CROMPTON.

(*Section G.—Mechanical Science.—Monday, September 10th.*)

IT IS unnecessary to again describe the earlier stages of the Brothers Cowles' invention of the electric furnaces. I confine myself to a description of such parts of the new plant which has been recently put down at Milton, near Stoke-on-Trent, that I think will be of general scientific interest.

The experience in America at the works at Lockport, Ohio, showed conclusively that great economies were to be expected from increasing the size of the furnaces and the strength of the electric current employed to work them, but no current larger than 3,000 amperes had been used up to the time that the Milton works were planned.

Mr. Eugene Cowles came over to England to ascertain whether English makers of dynamo machines were prepared to supply one 60 per cent. larger than Mr. Brush's "Colossus," which had been made especially for them in America, and which was then the largest direct current machine in the world. He prepared his specification for a dynamo to give a current of 5,000 amperes at 60 volts, and eventually Messrs. Crompton's design and tender were accepted. The works were built near the Milton Station on the North Staffordshire Railway. The boilers for generating the steam required are of the Babcock boilers type, and are provided with mechanical stokers. The steam-engine is of 600 H.P., and is a compound condensing horizontal tandem, made by Messrs. Pollit and Wigzel, of Sowerby Bridge. It is furnished with an exceedingly perfect centrifugal governor, which maintains the speed accurately at 76 revolutions, in spite of very great fluctuations in the load. The electrical means of stopping the engine has been provided in the shape of Tate's electrical stop valve, which may be described as an electro-magnet arrangement, with the ordinary pushes for completing the circuit, which actuates a steam relay piston set to close the main stop valve. The fly-wheel of this engine it 20 feet in diameter, and weighs 30 tons, and is geared to the pulley of the dynamo, so that the latter makes five revolutions for every revolution of the engine by rope-driving gear, consisting of 18 ropes. This engine is an extremely fine specimen of a modern steam engine. It works so silently that a visitor standing in the engine-house with his back to the engine railings at the time the engine is being started cannot tell whether it is in motion or not. The dynamo at first sight seems very small when compared with the steam engine driving it; the fact is that it is dwarfed by the enormous fly-wheel of the engine. It is only when one stands close to the plummer block bearings that one realises the great size of the spindle and of all the parts required to transmit the power to the armature coils. The author was well aware when designing this machine that the mechanical strains on the spindle core attachments and winding were likely to be of an extraordinary nature. The following precautions were, therefore, adopted, and, as events have turned out, these have been more than justified. The spindle is of steel, 18 feet long, with three bearings, one being placed on either side of the driving pulley. The diameter is 7 inches in the bearings and 10 inches in the part within the core. This part in the original forging was 14 inches diameter, and was placed longitudinally, so as to leave four projecting ribs or radial bars, on to which the core discs are driven, each disc having four keyways corresponding to these ribs. There are about 900 of these discs, the external diameter being 20 inches, and the total length of the core 36 inches. Originally the core was provided with 32 driving teeth made of steel, each tooth riveted to sockets attached to eight of the core discs. It may here be mentioned that, as the working has shown, the strain on these driving teeth was perilously near their factor of safety; their number has been doubled, so that now the tangential strains are borne by a very considerable number of the core discs. The armature winding consists of 128 copper bars, each ¾ inch deep, measured radially, by ¾ inch wide. These 128 bars are coupled up so as to form 32 conductors only; this arrangement has been adopted to avoid the heating from Foucault currents, which, with 1½ inch conductors, would have been very considerable. The bars are coupled at the ends of the core across a certain chord according to an arrangement patented by the author and Mr. Swinburne, which consists of crescent-shaped bars so formed that the whole surface is thoroughly exposed to the current of air passing through the armature. They are also somewhat shorter than those usually employed on drum-wound armatures. The bars are insulated by a covering of fiburite, a material which has been recently introduced by Messrs. Crompton, and which will stand a temperature of 160° C. for long periods without the least discolouration or alteration of its mechanical or insulating properties. The commutator is 20 inches long, has 64 parts, and, in addition to the usual tightening nuts at the two ends, is provided with a third tightening ring at the centre, to prevent the tendency of such long commutator strips to spring when worn down thin. The current is collected by eight brushes, mounted on a separate ring placed concentric to the commutator, and the current is led away from these brushes by a large number of bands of sheet copper strapped together into convenient groups. The field magnets are of the horizontal double type, and were adopted by the author and Mr. Swinburne, after a careful series of experiments which convinced them that the fashionable single magnet form was very unsuitable for this kind of machine. As this machine is virtually a series-wound machine, the magnet coils each consist of a few turns only of forged copper bars, 1½ inches wide by 1 inch thick, forged to fit the magnet cores. There is no insulation other than thin mica wedges to keep the bars from touching the core. The armature is ventilated by a current of air from a Shieles fan, driven by a belt from the armature spindle. At 380 revolutions the armature can give 5,000 ampères at 60 volts, and the temperature of the hottest part, which is the end plates next the commutator, never rises beyond 70° C. Although this machine was designed to give only 5,000 ampères, yet, electrically speaking, it is capable of doing very much more, and in actual practice it has frequently to stand a current of 8,000 ampères for short periods; but, as will be shown later, when the furnaces are employed to produce furo-aluminium there are frequently violent oscillations in the current which would make it unsafe to employ an average current much in excess of 5,000. In fact, as has been stated above, it has been found necessary already to increase the number of driving teeth in order to provide against the driving strains at the times of maximum current. When the machine was first tried the main circuit was unprovided with a cut-out, and there is no doubt that at this time the armature stood the test more than once of temporary currents exceeding 16,000 ampères. Since that time a safety cut-out has been provided calculated to fuse at 8,000 ampères. This —probably the largest one that has ever been designed—consists of a framework carrying 12 lead plates, and these fuse at the calculated point in a most satisfactory manner without any undue detonation or scattering of the molten lead.

Next to the cut-out comes the current indicator, which is simply a solenoid of 9 turns, through which the whole current passes. The core is attached by chain gear to the pointers, of which there are two, mounted on one spindle. One pointer and dial is placed in the engine room and the other in the furnace-room. The gearing of the spindle is calculated so that the range of the instrument up to 8,000 ampères extends over the entire circle of 360°. The construction of the solenoid for this indicator is somewhat novel. It is cut out of a cylinder of cast copper by means of a parting tool in a screw-cutting lathe.

There are two furnace rooms, each containing six furnaces, and the conductors, after leaving the current indicator, pass right across the two rooms at a height somewhat above the attendants' heads. The current is supplied to the furnaces as follows:—Each furnace pit consists of a long trough built of fire brick, the ends being closed by cast iron pipes, through which carbon electrodes are arranged, so that they can be moved lengthways to and fro by the attendant in charge. It will be remembered that one of the main features of the Cowles' invention is the use of limed charcoal as a lining for their furnace. They thus obtain a highly refractory non-oxidising lining, which is also a non-conductor of electricity, as the lime prevents the particles of carbon fusing together, and thus forming a continuous conductor, which would otherwise short circuit the furnace and be consumed under the action of the current, instead of the latter performing its proper duty of maintaining the furnace contents at the required high temperature. The electrodes, each of which consists of nine carbon rods attached to a cast iron head mounted on a copper rod passing through the above-mentioned cast iron pipes, are each provided with flexible copper wire cable connections, having an attachment sliding along the conductors, passing overhead and somewhat behind them. When it is desired to supply the current to any one furnace, the attachments are slid into position opposite it and clamped fast to the conductors. To start the furnace, the electrodes are brought together so as to touch, and then separated until the whole of the contents of the furnace between them is an incandescent mass at the required high temperature. The working of a charge in the furnace is carried out as follows:—The bottom of the empty furnace is covered with limed charcoal, the electrodes are brought into position, and a former or iron box, without top or bottom, and of a size determined by the space to be occupied by the charge is placed in the furnace; the ends of this sheet iron box are arched out so that it can be dropped over the electrodes. The furnace lining of limed charcoal is then rammed up in the space between the iron former and the furnace balls. The space inside the box is filled with the furnace charge, which, when ferro-aluminium is to be produced, consists of a mixture of charcoa', bauxite, and iron turnings, but when the cupro-aluminium is required, granulated copper is substituted for the iron turnings.

When the furnace lining and contents are brought up to the proper level, the iron former is carefully lifted, much as a moulder draws a pattern from the sand. The cover is then lifted on to the furnace, and it is then ready for the electric current. This, at first, is kept down to 3,000 ampères, but as soon as the charge is thoroughly burned through, and the furnace contents become incandescent throughout, the current is increased to 5,000 ampères, and in about one hour the reduction is complete. The reduced aluminium trickles through the furnace contents and collects at the bottom below the electrodes, from which in the furnaces last constructed it can be tapped out continuously. Mr. Cowles believes that the temperature of the centre of the furnace is so high that both the reduced aluminium and the metal with which it is to be alloyed are vapourised, and combine as a chemical compound when in this condition, being condensed in the upper and

cooler part of the furnace, and from thence passing down the sides to the bottom. The working of the furnace when cupro-aluminium is to be provided leaves nothing to be desired. The current can be steadily increased. Towards the commencement and towards the end of the reduction, the current is extremely constant, so that the load on the boilers, engines, and dynamos is fairly steady throughout, but when making ferro-aluminium, the conductivity of the furnace contents varies through very wide limits, and this brings heavy strains both on to the steam engine and dynamo, which must be met by correspondingly increased strength of parts. The chief feature of the process, which strikes a visitor to Milton works, is the small number of men necessary to work the process. Two men in the engine and dynamo room, one man at the boilers, and one boy to manipulate the electrodes of the furnaces, are all that are required for the active part of the operation. Two labourers can easily charge and relime the furnaces, and the remaining staff required for melting down, standardising, and casting into ingots the various classes of furnace products, is correspondingly small.

From the experience already gained, the author has no difficulty in designing and constructing engines and dynamos to supply currents of 15,000 or even 20,000 ampères, if such be required for Cowles' furnaces of enlarged size. The electrical difficulties met with in the construction of this large machine have been comparatively small, whereas the mechanical strains have been unexpectedly great, and must be provided for by extreme solidity and massive construction. Recent investigations made in America by Mr. W. J. Keep have shown that the use of ferro-aluminium is likely to be enormously extended when its properties in relation to cast iron are thoroughly understood and appreciated by the engineering world. Mr. Keep is a gentleman who is well-known in America, and his statements are entitled to be received with the utmost respect. We already knew in this country that the addition of ferro-aluminium to cast steel or to ingot iron in such proportion that the finished castings will contain not more than one-thousandth part of aluminium produced extraordinary effects, in some cases reducing the melting point 300° C., and in all cases imparting great fluidity to the metal, thus giving us sharp castings free from blow-holes, but it has remained for Mr. Keep to show us that the addition of an infinitesimally small percentage of aluminium to cast iron insures perfect castings, freedom from blow-holes, and almost all the ills to which the iron founder is subject. Mr. Keep's report is so very full that it is impossible to give any *resumé* of it here. I only call attention to it, and show the extreme importance that ferro-aluminium is likely to assume in future engineering, and that, as far as we know at present, the perfected Cowles' furnace is capable of producing the desired material in any quantity at a moderate cost.

ON A SYSTEM OF ELECTRICAL DISTRIBUTION.

By HENRY EDMUNDS.

(*Section G.—Monday, September 10th*, 1888.)

THE problem of the distribution of electricity has considerably occupied the attention of engineers lately, and several methods are in practical use, which may be classified as follows:—The direct low tension, in which currents of large volume are transmitted, requiring correspondingly large conductors. This system has the advantage of extreme simplicity, but is limited in its operations to short distances from the source of supply. Another is the secondary generator or converter system, in which alternating currents of smaller volume, but much higher tension, are used—lessening considerably the weight of conductors, and getting over the limit of distance, enabling comparatively small wires to supply electric energy over a large area, but attended with increased danger to life and property from leakage, and neutralising the saving of cost in copper, in the increased cost of insulation and protection of the conductors. Both these systems are, however, subject to the annoyance of fluctuation in case of varying pressure or total extinction of light due to stoppage of machinery, when all work would cease. And, if in order to minimise such accidents the generating plant be duplicated, the already large cost of machines, whose maximum output is only occasionally demanded, is enormously increased, thus adding to the capital invested and interest expected thereon.

In order to obviate the difficulties, inevitably connected with any system of direct supply, of being always dependent on the continuity and regularity of the motive power, accumulators or storage batteries have been proposed; as it is seen to be necessary to have the equivalent of the gas holder to the retort, or the water cistern or reservior to the spring or pump, in order to have a reserve independent of the source. This brings us to the question of how to supply batteries to the best advantage, and to examine into the methods hitherto employed on a large scale in connection with the public supply of electricity for lighting or other purposes.

In 1882 and 1883 I was in New York with the Brush Illuminating Company of that city, taking charge of the demonstration there of Mr. Brush's new system, which consisted in the employment of storage batteries, located in groups in series to each other, charged from a common main, carrying a 10-ampère current (the same being used to operate their arc lamps at night), devices being employed to automatically disconnect the batteries from the charging main when fully charged, and *vice versâ*. The idea being by this method to obtain double duty from their existing illuminating plant, and enabling them to charge batteries by day and run arc lamps direct at night, the charged batteries at the same time supplying current for incandescent lighting. But in actual practice serious difficulties soon presented themselves. The current employed for charging was too small, and there was not time to charge the batteries sufficiently during the hours of day for any great demand that might be made on them at night. Suggestions were made to obviate this by charging a larger number of small cells in series, and discharging in multiple. But this demanded correspondingly higher voltage pressure in the mains, and at the generating station, which presented very serious practical difficulties. Batteries being so charged could not be used to supply light locally at the time of charging. Thus removing the great desideratum in electric service, viz., continuous supply, and, further, the risk of breakage and damage therefrom was greatly increased; besides batteries under charge have an increased voltage, which either injures the lamps or causes annoyance by fluctuation. Ultimately, after great cost and expense, this promising system was abandoned; and I learnt, when in the United States a few weeks ago, has never been revived.

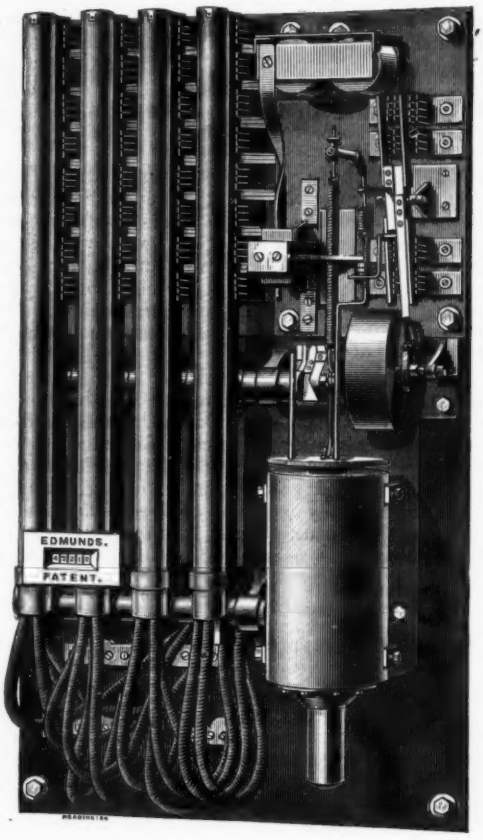
In England, also, experiments on a large scale were made at Colchester about the same period; here batteries were charged with a high pressure charging current of small volume—duplicate sets of cells were employed so that one set was being charged from the main while the other was discharging locally. But again difficulties presented themselves in practice. The pressure at the station or the charging mains being at least equal to the sum of all the batteries in series was either very high, or else limited, the number of groups on circuit that could be charged at one time, also the freshly-charged cells having a higher E.M.F. than those that had been discharging caused serious fluctuation in the lights during the change from the main to the local. And as the cells automatically changed their position from the main to the local only when they had themselves arrived at a certain condition of charge, sometimes the local cells had got over discharged, causing serious damage through buckling and deterioration generally. The result was that the Colchester system was ultimately abandoned.

Having thus far glanced at the history of electrical supply, I now turn to the method proposed and patented by myself known as the Edmund's System of Electricity Distribution, such as is now being employed in actual practice by the Cadogan Electricity Supply Company, London. This system differs essentially in every point from any of the plans hitherto tried or in operation at the present time, and may be thus described:—

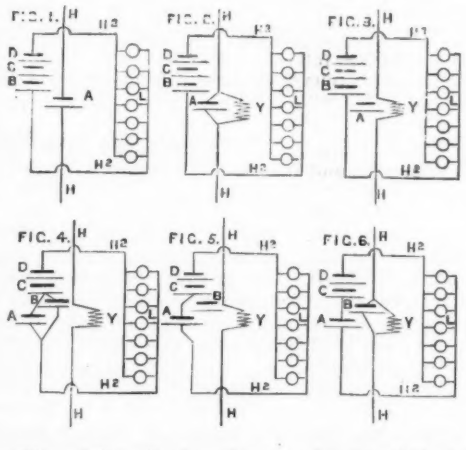
A number of groups of cells, which we will call the local batteries, are placed at different points or centres where supply is required in the district, each battery having its individual number of cells according to the voltage required locally, and the amount of current to be supplied. Unlike the Brush method referred to, these local batteries are electrically distinct and independent of each other and of the charging main, neither is there a duplicate set to be changed as at Colchester, but instead, we employ an additional group with each of the local batteries, which we will term the main batteries, the number of cells of which are a divisor of the number employed locally—generally one-third. For example, suppose the local voltage be 48 volts, 32 cells would be employed which we would subdivide into 4 groups, 8 cells in each, and for purposes of identification we will call these groups *a*, *b*, *c*, and *d* respectively. Groups *b*, *c* and *d* are connected in series in the local (see diagram) giving 48 volts. Group *a*, being in the main, being charged for a limited period of time—in practice 2 minutes—is then removed from the main charging circuit and placed it in the local discharging circuit, when say group *b* is removed from the local into the main to be charged. *b* now in turn exchanges places with *c* and *c* with *d*, so that each group *a*, *b*, *c*, *d*, follow each other in turn from the main to the local or local to main, whereby in every 8 minutes each group has received its increment of charge from the main and has supplied the same in turn to the local, and so on continuously, until in 24 hours each group has received its full charge of current, enabling the battery to maintain its maximum discharge for eight hours. The current employed in practice being 70 ampères, and the size of cells proportionate. Incidentally we find many advantages due to charging cells in this manner. We can maintain a constant potential on the local circuit, so that we have not the interference and fluctuation due to charging and discharging at the same time. The high tension main is never at any time in electrical contact with the local circut, thereby freeing the system from leakage to earth and its attendant danger. Also the cells are kept in much better condition by continually receiving short increments of charge and having periods of rest from discharge. The loss due to difference of potential between the charging and discharging current is minimised, it being found in practice we can continue charging the cell to its maximum capacity with a mean voltage of 2·25, instead of 2·5 per cell as is required, where cells are charged continuously. This, on a large scale is a considerable element of economy, where there are a number of cells in the charging main. Also we find that an approximately constant potential on the local circuit enables us to run lamps at a higher efficiency, without the risk of rupture due to sudden rises of pressure; and so far as we can judge the life of the batteries is considerably lengthened by this mode of intermittent charge and rest. And in addition to all these advantages we have a great saving in the generating station in cost of plant, only one-third the power being required to operate the same number of lights for eight hours, that would be necessary for any direct system, and much less electric force or pressure on the charging mains to supply the same number of lamps, thereby saving cost of installation and chance of leakage.

The additional advantage of being able to run a smaller station for 24 hours in the day is obvious, as we do not have any idle plant

with interest thereon. The current being always constant in volume enables a single main of one size throughout to be used, preventing complications and only requiring increase of pressure as the work extends, which pressure would be only one-third the Brush or Colchester systems referred to, for the same number of cells in the local centres, or could at their pressure charge three times the number of batteries. For example, where batteries are used in 100 centres on the Brush or Colchester plan, each centre giving 50 volts, requiring at the station a charging potential of over 5,600 volts exclusive of the line, while with the distributor plan it would only require a charging potential of under 2,000 volts for the same work.



The apparatus for carrying out this system, I call a distributor —it combines in one instrument a time mechanism causing changes to occur at regular periods of say two minutes, by energising an electromagnet at each period, rotating a shaft carrying cams that cause levers to make the necessary contacts for changing



the position of the cells from local to charge and *vice versâ*; a polarised switch, whereby the current is prevented from entering the batteries in the wrong direction, and a voltage regulator which causes the batteries as a whole to cut themselves out of the charging main or otherwise, according to their being fully charged, or requiring charge. A simple form of meter registering the current is supplied. The diagram of the cycles of operation will explain what takes place, and I have constructed several distinct instruments for effecting these cycles, some with levers and mercury contacts, one with rotary brush contacts like a compound commutator, and the one shown in cut which we are now using, in the designing of which I have received great help from my assistant engineer Mr. Albert Howard.

The manner of effecting the cycles is explained by diagrams 1 to 6 A. B, C, and D represent the accumulators at one point of lighting, which are divided into four equal groups. For instance, imagine there are 32 cells in one house, then A group would consist of 8 cells connected together in series, and B, C, and D the same.

In diagram 1, A is receiving a charge from the central station, over the main cable, B, and batteries B, C, and D are connected together in series and furnishing current to the lights, B. After this state of discharge has been in operation for a fixed interval of time, the distributor begins to work automatically and makes the various connections necessary, as follows:—

Fig. 2. A resistance, I, has been switched into the main circuit in parallel with battery A.

Fig. 3. A has been switched entirely out of circuit, leaving the main current of 70 ampères, which have never been interrupted, flowing through the resistance, Y.

Fig. 4. A has been switched into parallel with B in the local or discharge circuit. This is done without the slightest alteration in the lights, as the electromotive force remains the same as before.

Fig. 5. B has been cut out from the discharge circuit, leaving the lights on to A, C and D.

Fig. 6. B has been connected into the main charging circuit in parallel with the resistance, Y.

The resistance, Y, is then disconnected, leaving the charging current flowing through B, which receives a charge for the fixed interval of time, and is then switched back into the local circuit, while C receives its increment of charge. In this way each section of the batteries passes through equal periods of charge and discharge.

The time occupied in the mechanical movements of the entire cycle is three-quarters of a second, and the period during which the charge is on can be varied at will.

Such a system as I have briefly described lends itself to many purposes in connection with electricity supply. For instance, in the working of railroad switches and signals, electrically, a distribution at each block station would enable a whole line of rail, say 200 miles, to be supplied from one source, the pressure on the main being only a small fraction of the sum of the local pressure; or in electric tramway work, a charged main, well insulated, of high pressure, could supply a number of points *en route* which in turn could each, independently of the other, supply large volume low pressure currents locally—saving risk of breakdown and consequent interruption of traffic.

But more particularly is it useful in detached house and suburban lighting, for it solves the problem of giving each house its own individual supply of electricity continuously day and night, totally independent of continuous or regular working at the central station or of interference from other work on the same circuit, being at the same time absolutely safe from the danger of shock, and, above all, supplying the electric light at a reasonable cost.

NOTES.

Mill Lighting.—Some time ago the directors of Sowerby Bridge Flour Society decided to put the electric light into their mills, and the plant has been put in by Messrs. Blakey, Emmott & Co., of Halifax. The dynamo gives a current of 130 ampères at 95 volts, and runs at a speed of 600 revolutions per minute. It is so arranged that it can be run from three different engines. There are about 200 lights in the mill, of which the majority are of 16 candle-power. One of the chief features of the work is about 30 hand lights, which the men use for examining and cleaning the various machines. There are large lamps, varying from 40 to 60 candle-power, placed outside the offices, mill yard, and yard adjoining the joiner's shop. A trial was made last week, which proved very satisfactory.

The Electric Light Goes Out.—The electric light in the Assembly at Hobart Town completely failed at a critical moment during a division recently, and the House was left in a state bordering on darkness for a few minutes. The cause was the breaking of the driving belt between the engine and dynamo. The belt was one left by the company who supplied the plant, and was said to have been made of very rotten leather, and but for the precaution taken by the Messrs. Kennedy, who have charge of the installation, in having another driving belt at hand, there would not have been any more electric light during the evening.

Electric Light in Australia.—The residents of Tamworth, New South Wales, are preparing to celebrate the inauguration of the electric light, and the Governor will probably turn on the light.

Electric Lighting in the Navy.—The official trial of the electric light machinery on board H.M.S. *Britannia* and *Hindostan*, stationed at Dartmouth, took place on the 4th inst. All the main cables and branch wires are lead covered throughout. The total number of 16 C.P. incandescent lamps is 462, distributed over the two vessels in such a manner that oil lamps are entirely superseded. Current is supplied by a Siemens dynamo, giving 80 v. and 400 amp., driven by a Willans' engine, the steam being generated in a boiler of the locomotive type, made and fixed by Messrs. Hornsby and Sons. The lights required during the night after 10 p.m. are supplied with current from a storage battery of the Drake and Gorham type. The whole of the wiring and fitting of these vessels has been executed by Mr. R. A. Scott, of Hammersmith, who this week has commenced work on two more of H.M.S., viz.:—the *Magicienne* and *Marathon*, which are now in course of construction at Glasgow.

The Lighting of the ss. "Islander."—This vessel is throughout lighted with electric light by Messrs. Paterson and Cooper. The generating plant consists of a Phœnix dynamo for 250 lamps, and an Archer engine. There are 220 lamps, which are arranged in eight circuits to suit the requirements of the vessel, and any part of the ship can be lighted independently of the others. The conductors are laid on the double-wire system, and every necessary is provided to make the installation of the highest quality and workmanship.

Ship Lighting.—The ss. *Ivy*, the latest edition to the Laird's Line, has been fitted with a complete installation of the electric light by Messrs. William Harvey and Company, Broomielaw, Glasgow.

Messrs. Paterson and Cooper have recently put in, or added to, installations on the steam yacht *Tigh-normasa* (on which accumulators are fitted), the Clyde saloon steamer *Victoria*, the training ship *Mars*, and two steamers named *Dundee*, belonging, one to the Dundee, Perth and London Shipping Company, and the other to the Tay Ferries Steamship Company. Contracts are in hand for lighting the *Cambria* and three other vessels, so that Messrs. Paterson are well occupied.

Mill Lighting.—Messrs. Paterson and Cooper have just completed an installation in the Guard Bridge Paper Mills.

Theatre Lighting.—Messrs. Howard and Wyndham, by way of completing the overhaul of the Theatre Royal, Glasgow, intend to introduce the electric light.

Bridlington and the Electric Light.—At the last meeting of the Bridlington Local Board the question of lighting the Sea Wall Parade with the electric light was discussed, and a resolution passed instructing the committee to ascertain upon what terms it could be done.

Lighting a Village by Electricity.—On Saturday night a very successful experiment was carried out at Hapton, in Lancashire, the village being lighted by electricity. Mr. Simpson, jun., and a few others were desirous of having the village illuminated with electricity, and procured the necessary plant for the purpose. The effect was excellent, and pleased the inhabitants very much. It has been suggested that the village should be constantly lighted with electricity instead of with gas.

Telephonic Development in Germany.—The correspondent of one of the daily papers, telegraphing from Berlin on Tuesday last, mentions that the newly-laid telephone line between Berlin and Breslau was opened on that day. It is the longest in Germany, covering a distance of about 360 kilometres, or approximately 225 English miles.

Telephonic Enterprise in the South.—The Western Counties and South Wales Telephone Company is making satisfactory progress with its scheme for establishing trunk lines between Bournemouth, Winchester, Southampton, Portsmouth, and Gosport. Permission has just been granted by the Fareham Local Board for the erection of poles and wires over that portion of the route coming within its jurisdiction, subject to an exchange being opened in the town.

The Telephone in Scotland.—The National Telephone Company has now put Dunfermline in telephonic communication with a number of the villages in West Fife, comprising Cowdenbeath, Aberdour, and Burntisland. It is also the intention of the company to switch on all the colliery offices on the route, should the coalmasters become subscribers.

The Telephone in Aberdeen.—Since an Exchange was opened by the National Telephone Company, Limited, in Aberdeen in 1881, the system has made extensive progress in the city. The company have now 580 telephones in use in the district, and the total length of the wires is nearly 380 miles. During the busy parts of the day the number of conversations which are held amounts to over 600 per hour. The average number of calls is about 3,000 per day.

Cheltenham and the Telephone.—At the monthly meeting of the Cheltenham Town Council the matter of a telephone exchange was again discussed, together with an application from the Telephone Company for permission to erect poles along the highway from Badgworth boundary into the centre of the town for the purpose of carrying a trunk line from Gloucester to Cheltenham, and it was resolved that the whole matter stand over for consideration at a special meeting of the committee.

Defective Telegraphic Arrangements.—For some time past the defective postal and telegraphic arrangements which exist at Barnstaple have occasioned general dissatisfaction, and the Town Council and local press having made some urgent representations on the subject, Sir A. Blackwood has promised to duly consider the matter. At present the telegraph office closes at eight o'clock, and there is no resident telegraphist on the premises. Before a press message can be dispatched at a late hour, the town has to be scoured for the particular clerk whose turn it is to "hold the key."

Telegraphic Extension to the North.—Telegraphic communication has now been opened with Durness, Sutherlandshire, and it is expected to be extended shortly to Scourie and Cape Wrath. Ships obliged from stress of weather to take shelter in Loch Eriboll can now easily give notice of their whereabouts to those interested.

Threatened Strike of Paris Telegraph Operators.—The *Daily News* Paris correspondent telegraphs:—"*La France* states that the telegraphic clerks and operators at the central Paris office are on strike. On making enquiry I find that this news is not correct. Nevertheless, I should not be surprised if something of the kind were to take place, as great discontent is being shown by Post Office servants at the way in which promotion is made. Last night between 500 and 600 clerks and operators of the central office met at the Salle Eliot to discuss their grievances. One of them said that 6,000 were ready to join in with them."

A Submarine Torpedo Boat.—A Reuter telegram from Cadiz, dated September 8th, reads thus:—A submarine vessel invented by Lieut. Peral, of the Spanish navy, was launched from La Carraca arsenal here to-day. The vessel, which will be completed next month, is cylindrical in shape, and of 87 tons register, and is provided with twin screws, an electric engine, and a torpedo tube.

Sprague Electric Plant for Mines.—At the Aspen Mines, Colorado, a Sprague motor operates a train of from five to nine cars, bringing in the empties and regulating the speed of the outgoing loads, the generating plant being 6,500 feet distant. A Pelton wheel is operated by water from a flume only 70 feet above it, the volume of water cast against the wheel being regulated by what is called the Woodward governor. This keeps the speed of the dynamo nearly constant by raising or lowering the nozzle which supplies the water to the wheel, according as the strain is given or slacked by the engineer in the tunnel a mile and a quarter away. From the shaft of the Pelton wheel a belt runs to and drives a 500-volt Edison dynamo, which changes into electrical energy 92 per cent. of the power of the wheel. The loss in transmission is calculated at about 10 per cent., and the energy at the motor pulley 74·5 per cent. of the water taken from the water-wheel. The motor is rated at 10 H.P., and capable of exerting 15 to 20 H.P. The plant gives such entire satisfaction as regards promptness of action and economy, that a duplicate is shortly to be erected in another part of the same tunnel.

Electric Traction in Paris.—*La Cocarde* of the 8th inst. says:—"The Northern Tramways Company will commence next Monday to run some new cars propelled by electricity. These cars, which were tried last Wednesday, will carry 52 persons." We shall watch with interest the results of these trials and shall be glad to receive further particulars of the "system" employed.

Charterhouse Science and Art Schools.—The winter session of this, one of the largest science and art schools in the United Kingdom, will commence on Saturday, October 1st, 1888, under the presidency of the Rev. Henry Swann, M.A. During the late session upwards of 1,000 students, mostly elementary teachers, availed themselves of the privileges afforded by this institution, and of this number nearly 700 presented themselves for examination and were successful in obtaining a large number of Class Certificates and also a fair number of Honours Certificates awarded by the Science and Art Department of South Kensington.

New Electric Lighting Station.—The directors of the House-to-House Electric Light Supply Company, Limited, have decided to accept the tender of Messrs. Peto Brothers for the erection of their first central electric lighting station at West Brompton, and the building will be completed by the middle of November.

Electric Traction in Philadelphia.—President Barr and the directors of the Lombard and South Streets line of railway in Philadelphia have decided to introduce the Reckenzaun electric motor on the eastern end of their line. They say that the electric car will do far more work than an ordinary horse car, at about half the cost. Several orders for electric cars have been received from other cities, and a large business in the construction and sale of these cars is anticipated.

Electrical Distribution Schemes.—Does not the following extract from the *New York Electrical World's* record of electrical patents cover much the same ground as the elaborately wrought scheme of Mr. H. Edmunds?—"387,988. Apparatus for charging and discharging secondary batteries. M. Pfatischer, of Philadelphia, Pa., assignor of one-half to Wm. T. Brown and William Kirk, jr., both of same place. Application filed November 18th, 1887. This invention contemplates the operation of each independent battery, at will, from the central station. Rotatable cylinders having electrical contacts for cutting the batteries into the charging circuit, and additional contacts for cutting the lamps into the battery circuit, are located at each outlying station, and are controlled from the central generating station."

The Lighting of the Brighton Pavilion.—Threatened Litigation.—At the last meeting of the Brighton Town Council, the Pavilion Committee reported the receipt of a letter from Messrs. Gresham and Davies, solicitors, informing them that they had received instructions to enforce the claim of the Maxim-Weston Electric Lighting Company, against the corporation, and enquiring whether the corporation were prepared to settle the amount. The committee added that they had referred the communication to the Town Clerk, the corporation solicitor, and Alderman Lamb. Councillor Broadbridge, in drawing attention to the matter, expressed a hope that the Council would be given some information before the matter was permitted to go very far. Two of the gentlemen to whom the matter had been referred were lawyers, and they all understood how fond the latter were of running up bills of costs. If the Council did not watch the matter carefully, they might find themselves involved in a lawsuit, without having an opportunity of saying whether they would like to take the matter into Court or not. Councillor Botting observed that it would be as well to refer the dispute to an arbitrator. Alderman Abbey, who replied on the discussion, said that it would be improper for him to make any statement on the question, considering there was a probability of litigation. The gentlemen to whom the question had been referred would, when they had sufficiently considered it, make their report. The clause was then adopted.

Dundee Fire Alarms.—The new electric bell fire alarm arrangement at Dundee was put to its first practical test last week. The apparatus was found perfectly satisfactory, and the men were summoned to the Police Office and turned out in a remarkably short space of time. The apparatus at the Police Office, consisting of two magneto-electric machines suitably fitted, is driven by a heavy weight, and is connected by wires with electric bells in the houses of 16 firemen in various parts of the town. On an alarm of fire being received by telephone or otherwise at the Police Office, the attendant has only to pull out a pin and immediately the apparatus starts automatically to ring simultaneously the whole 16 bells at the firemen's houses, and these continue to ring loudly for nearly one minute. This arrangement has been introduced by the National Telephone Company in several other towns.

An Enlightened Board.—On the suggestion of the captain of the Fire Brigade, the Otley Local Board has decided to establish telephonic communication from his house to the public fire alarm at the gas works, and also to the house of Col. Dawson (Weston Hall), where there are a brigade and a fire engine. The Board has likewise appointed a committee to report on the advisability of supplying electric light to the town, water being the power used.

University College, Dundee.—In his report on the last session, the principal states that good solid work has been done, and that of the day students 25 matriculated at St. Andrews University, with the view of proceeding at the end of their course at Dundee to the degree of Batchelor of Science. The report proceeds, "As the throwing open of other degrees, so far as our equipment may enable us to take advantage of them, is only a question of time, the success of the college as an academical institution, doing work of the University standard, may be regarded as fully assured." A department of dyeing and bleaching is now added and the engineering and mechanical laboratories have been completed. The special laboratory for the practical teaching of electrical engineering, is fitted out with all the requisite apparatus to enable students to become familiarised with practical methods of electrical testing, and of measuring currents, electromotive forces and resistance, the efficiency of dynamos, motors and storage batteries, the ratio of candle-power to horse-power in electric lamps, and the conductivity, insulation, and capacity of conductors according to the method practised in cable factories and telegraph stations.

The Graphophone and Phonograph.—On Thursday of last week these instruments were exhibited to the members of the British Association, and once again Colonel Gourand cleverly contrived to overshadow with his discourse on the phonograph that which followed upon the rival apparatus. There can be no doubt, however, but that the graphophone as a talking machine has great advantages; its reproduction of articulate sounds is more distinct, its construction is much simpler, and the necessity for a cumbrous battery with its electric motor, as was used in the case of the phonograph, entirely obviated.

Navigable Balloons.—The Paris correspondent of the *Times*, telegraphing on Monday says:—The *Figaro* to-day publishes a paragraph in which it is stated that a method of steering balloons has at length been discovered by M. Renard. A balloon is in course of construction at Meudon, which will prove the reality of this discovery. This balloon will be furnished with a new motor, 500 kilogrammes in weight, of 50 horse power, which, it is anticipated, will be capable of producing a speed of 100 kilomètres (upwards of 60 miles) an hour. The balloon will thus be navigable in any direction and in any weather, except when it is actually blowing a gale. The previous experiments of M. M. Renard and Krebs with the electrical propulsion of balloons, will doubtless be remembered by our readers.

Special Telephones.—Under this heading we briefly noted in our last issue that two telephones had just been completed by the Consolidated Telephone Construction and Maintenance Company for the King and Queen of Portugal. The cases of these instruments are made of West Indian rosewood, which, though not much seen in this country, is very suitable for high-class cabinet work, and has a beautiful appearance when polished. This material had to be employed in order that the cases should harmonise with the furniture of the Royal Palace. The two instruments are chastely gilt, and the two gongs in front of each are of silver, beautifully figured. Though alike in all other respects, the cases are distinguishable by the ornamentation, the one intended for the King's use bearing the Portuguese arms alone, the receivers being covered with silk of the Portuguese colours, white and blue; while the Queen's telephone has on its front a combination of the Portuguese and Italian coats of arms, and the receivers are covered with a combination of white, blue, and green silk. The telephones are of the Gower-Bell type, and the parts are arranged on what is called the Austrian pattern, the magneto bell being at the top, with the transmitter below, and under that the battery box, the receivers hanging at the sides. The magneto bell is adjusted to ring through 12,000 ohms resistance, and is made with the latest improvements, some of them apparently trifling in themselves, but all contributing to thorough efficiency. For instance, instead of trusting to the contact made, not altogether infallibly by the closing of the hinges, it is now the practice to affix a small spring piece to the door half of the hinge, so that good contact is made a matter of certainty. The toothed wheel gearing of the magneto bell has also been improved. The transmitters are of the usual Post Office pattern of the Gower-Bell, the iron parts being brassed by a galvanic process rendering them both more sightly and more durable. This process of covering the iron parts with a plating of brass is now being generally applied in the construction of telephones by the Consolidated Company, especially those intended for exportation to countries where the atmosphere is humid.

Telegraph Supplies.—The Great Western Railway Company requires tenders for telegraph poles, wire, instruments and materials. Samples and patterns may be seen after 17th inst. at the office of the Storekeeper, Paddington Station. Tenders will be received on or before October 1st.

Electrically-Refined Sugar.—The New York correspondent of the *Financial News* telegraphed the following on the 7th inst.:—A trial of the new electric sugar process took place to-day. I am told this evening at the office of the Electric Sugar Refining Company that 13 barrels of an average of 325 lbs. each were refined in one hour and ten minutes. This is practically the first test of the new process. Three sizes of refined sugar were produced, and as a result the company claim that the process is established, and the machinery to operate it. Mr. Willett (a prominent sugar merchant in this city) witnessed the experiment, and says:—"At the trial about 13 barrels of refined sugar of various grades were produced, by every appearance to experts being freshly-made sugars. Visitors were not allowed to inspect the machinery, or take any precautions against deception; but their confidence in the success of the manufacture was increased by what they saw. The sugar produced was beautiful in colour, entirely dissimilar from any refined sugars produced by refiners in America. Three different grades ran from one granulator. Four more grades were exhibited as having been produced at the same time in a private room from the same operation, all having the appearance of freshly made sugar. As far as the experiment went it was satisfactory, but not conclusive. The strain on the new machinery prevented a larger product. The time taken for the conversion from raw to refined sugar was 25 minutes. One barrel of refined sugar was filled every two minutes." I am told, further, that the experiment was hastened to-day in order to accommodate certain parties before leaving this country. A much larger experiment will be made in about a month.

The Copper Ring.—We quote the following from the *Financial Times* of the 11th inst.:—"The ELECTRICAL REVIEW of Saturday last, referring to the future of copper, quotes, side by side, the views of the *Financial Times* and those of a daily contemporary, heading the quotation, 'Two Opinions—Which is Correct?' To-day's telegrams as to the difficulty of placing orders except through the syndicate, and the firm position of the copper market, at any rate so far, fully bear out our opinions on this subject. Copper shares have not yet reached anything like their 'top-price.'"

City Commission of Sewers.—On Tuesday a meeting of the City Commissioners of Sewers was held at the Guildhall. An application from the East Strand and District Electric Light and Power Company for the Commissioners' consent to the application they are about to make to the Board of Trade for a provisional order or licence to supply electricity in the portion of the City from Farringdon Street and New Bridge Street westward was referred to a committee, as was also an application from the London Electric Supply Corporation for the Commissioners' consent to a licence being granted to them by the Board of Trade for the supply of electricity within the City.

Another Opening for the Electric Light.—The Castleford Local Board (Yorks.) is prepared to enter into communications with electricians and others with a view of supplying the market and street lamps with other than gas light. Further information can be obtained by applying to Mr. H. H. Broadbent, clerk, Castleford.

The Electrical Transmission of Power.—Professor Ayrton's lecture, last Friday, was such a pronounced success that numerous applications were made to the local secretaries for a repetition, and this the Professor consented to give, the date being fixed for yesterday. We hope to print the salient points of Professor Ayrton's discourse in our next issue.

Cable Repairs.—A Reuter's telegram, dated Bombay, Sept. 11, says:—Telegraphic communication between India and Europe, *viâ* Egypt, has to-day been restored, one of the Bombay-Aden cables of the Eastern Telegraph Company having just been repaired.

Electric Signals.—The contract for the erection of electrical controlling apparatus and signals in connection with the machinery in a new granary, built by the Docks Committee of the Council of the City of Bristol, has been secured by Messrs. King, Mendham & Co., electrical engineers of that city.

Removal.—The London Electric Supply Corporation has removed to new offices at No. 3, Adelphi Terrace, Strand, the present offices at No. 79, Grosvenor Street, being no longer sufficiently large for a rapidly increasing business. The new central generating station of the Corporation at Deptford is approaching completion, and it is understood that the directors will be able to furnish a largely increased supply of the electric current before the close of the year.

NEW COMPANY REGISTERED.

Sheffield Telephone Exchange and Electric Light Company, Limited.—Capital: £60,000 in £10 shares. Objects: To purchase from John Tasker, of Sheffield, the goodwill of the Sheffield Telephone Exchange and the Rotherham Telephone Exchange, established by Mr. Tasker, and the business of dealer in, and of leasing or letting telephones and telephonic apparatus and wires, and the business of supplier, fixer, and fitter of electric light and power, electric bells, electric colliery signals, lightning conductors, and other electrical apparatus and appliances. Signatories (with 1 share each): *John Tasker, *John Gamble, *J. Senior, J. Burdekin, *G. Franklin, J. Jonas, J. F. Smith, all of Sheffield. The signatories denoted by an asterisk, and Mr. Wm. Tasker, are the first directors. Qualification: 20 shares. The directors may divide £300 per annum as remuneration for their services. Registered 11th inst. by Meredith & Co., 8, New Square, Lincoln's Inn.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

Tunbridge Wells Electric Light Company, Limited.—The statutory return of this company, made up to 12th June, was filed on the 1st August. The nominal capital is £30,000 in £5 shares; 16 shares have been taken up, but no call has yet been made, consequently the paid up capital is nil. Registered office, 43, London Road, Tunbridge Wells.

Thorneburry Light Company, Limited.—The statutory return of this company, made up to the 20th ult., was filed on the same day. The nominal capital is £20,000 in £5 shares. The only shares at present taken up are the seven subscribed for by the signatories to memorandum and articles of association, and upon these the full amount has been called and paid. Registered office, 85, Gracechurch Street, E.C.

Manchester Edison-Swan Company, Limited.—The annual return of this company, made up to the 3rd inst., was filed on the 4th inst. The nominal capital is £550,000 divided into 50,000 A shares of £9 each, and 10,000 B shares of £10 each. The shares taken up are 20,000 A and 10,000 B, and upon the former £1 per share has been called up, and the full amount upon the latter. The total of the calls paid is £20,000 upon the A shares, and £100,000 upon the B shares.

West Middlesex Electric Lighting Company, Limited.—The annual returns of this company, for the last four years, were filed on the 4th inst., the latest is made up to the 19th December, 1887. The nominal capital is £100,000 in 20,000 shares of £5 each. 524 shares have been taken, and of these 400 are considered as fully paid, and upon the remaining 124 shares the full amount has been called. The calls paid amount to £355, and unpaid to £265, the latter amount being due upon 53 shares. Registered office, Caxton House, The Grove, Hammersmith.

Chatham, Rochester, and District Electric Lighting Company, Limited.—The annual return of this company, made up to the 3rd inst., was filed on the following day. The nominal capital is £10,000 in £5 shares, the whole of which are taken up. The following calls have been made: Upon 7 shares, £5 per share; upon 738, £3 per share; upon 1,255, £2 per share. The calls paid amount to £4,202 10s., and unpaid to £566 10s. The sum of £10 has also been paid in anticipation of calls. Registered office, Victualling Office Wharf, Rochester.

Gülcher (New) Electric Light and Power Company, Limited.—At an extraordinary general meeting of this company, held on the 9th, certain alterations were authorised in the articles of association, the principal being a provision for payment of a preferential dividend of £10 per cent. per annum on the preference shares. The voting powers of members will in future be as follows: One vote for each share up to five shares, one vote for every additional five shares up to fifty shares, and one vote for every ten shares beyond that number. The resolutions were confirmed on the 27th ult., and were duly registered on the 10th inst.

National Telephone Company, Limited.—The annual return of this company, made up to the 18th August, was filed on the 5th inst. The nominal capital is £750,000, divided into 90,000 ordinary shares of £5 each, 15,000 first preference shares of £10 each, and 15,000 second preference shares of £10 each, the whole of which have been taken up. The full amount has been called upon the ordinary and first preference shares, and £6 per share upon the second preference. The total amount of calls paid is as follows: Upon the ordinary shares £450,000, upon the first preference £150,000, upon the second preference £89,990, leaving £10 unpaid.

United Telephone Company, Limited.—The annual return of this company, made up to the 3rd July, was filed on the 5th inst. The nominal capital is £500,000, in £5 shares. 99,022 shares have been taken up, and the full amount has been called and paid thereupon, the paid up capital thus being £495,110.

LEAMINGTON LIGHTING REDIVIVUS.

WE notice in the Birmingham *Daily Gazette* of the 11th inst. the following, which is too good to be lost to the electrical world:—

At a meeting of the Leamington Corporation last evening, the following letter was read from Messrs. Shippey Bros., electrical engineers:—

"Dear Sir—Professional etiquette would have prevented us writing to you on the subject of lighting any part of Leamington, but as we perceive Mr. Chamberlain has publicly stated that he does not care to light certain portions of the town, we consider it therefore opens up a road for others to come in and secure the work if possible, and show their systems of lighting, which are known to be far ahead of the Edison and Swan lamps used by the contractors. We may say that our firm controls the Waterhouse system of electric lighting, and if we are permitted by the Town Council we shall be happy to put down either a 30, 40, or 60-light plant at our own cost, and show the merits of the system on the spot. The most successful manner of lighting is to use arc lamps for street lighting and 50 or 100 C.P. incandescent lamps for shop lighting, and 16 C.P. for domestic purposes, and when this combination is introduced Leamington will stand on a par with Berlin and other cities on the Continent which have adopted the system for which we are British agents and contracting engineers. In America the Waterhouse system has made greater strides during the past twelve months than any other system, including such eminent places as Washington, Baltimore, Newark, New York, and Cleveland, which, as you are probably aware, is the home of the Brush Company, which fact

we think is good evidence of the merits of the Waterhouse over other systems for arc or incandescent lighting. If our preliminary proposals can be entertained, our Mr. Arthur Shippey will be happy to come down to Leamington by appointment, and can then fully discuss the matter with those having control of the lighting department of your district. — (Signed) SHIPPEY BROTHERS."

The letter was referred to a committee of the complete Council, who met at the close of the ordinary business and discussed at great length the whole question of the lighting of the borough, but did not make public the decision at which they arrived.

It seems almost time that Messrs. Shippey Bros. engaged a correspondent able to pen a few lines of decent English, for this blending of systems, Edison-Swan lamps, and eminent places is delightfully *naive* and shows the utter contempt with which the writer regards the ordinary rules of grammar. The evidence adduced to prove the merits of the Waterhouse system is worthy of a Philadelphian lawyer, but some of the statements with respect to the strides of the Waterhouse Company appear to be made out of "sheer cussedness" or in ignorance of the actual state of affairs.

THE CABLE BETWEEN GJEDSER AND WARNEMÜNDE.

THIS cable, which was ordered by the Danish and German Telegraph Administrations for connecting the two nearest points on the Danish island of Falster and the German coast at Warnemünde, was successfully laid on the 3rd inst. by the Great Northern Telegraph Company's cable steamer the *H. C. Oersted*. The cable was made by Messrs. Felten and Guilleaume, and was transported in 12 large railway trucks from the works of this firm at Mülheim-on-the-Rhine to Warnemünde, where they were run alongside the quay and the cable coiled direct from the trucks into the ss. *Oersted*. The whole length taken on board was 27 knots, with a total weight of 240 tons, and of this 24 knots were payed out between Warnemünde and Gjedser. The main cable weighs about nine tons per knot, and there is 450 yards of heavy double sheathed shore end at Warnemünde, but no shore end on the Gjedser side. The cable contains four light cores with G. P. as the insulating material; two of these are intended for a direct Copenhagen-Berlin connection, one is connected to the railway station at Gjedser and the Post Office at Warnemünde, and one is kept in reserve.

The cable was perfect, electrically and mechanically. At 5 o'clock on Monday morning of the 3rd inst. the *H. C. Oersted* commenced to land the shore end at Warnemünde, and at 5 o'clock in the afternoon the other end was put ashore at Gjedser, and communication between the two shores established, thus affording the means of a new and direct communication between Copenhagen and Berlin, and also a valuable connection between Gjedser and Warnemünde, which points have had a regular daily service of fast mail steamers in operation for the last two years.

LIGHTNING.

By S. A. VARLEY.

(*Continued from page* 260.)

IN reference to the behaviour of the lightning discharge which struck the vane rod of Doncaster Church, and the phenomena which have come under my own observation, where telegraph circuits having multiple protectors have been struck, I have suggested by way of explanation that something of the nature of momentum is produced by the electrical motion set up in the atoms composing the conductor. I do not wish it to be considered that the explanation attempted is other than a mere suggestion.

What occurred at St. George's, Leicester, and Doncaster Church can be explained by Prof. Lodge's alternative path experiments, but that described in reference to multiple protectors cannot, I consider, be so explained. What there takes place is very suggestive of an actual blow being struck, and resembles what occurs when a metal rod receives a sudden mechanical impact.

If a metal rod, A, A^1, fig. 7, be mounted on a stand, S, firmly fixed to a bench to prevent longitudinal motion, and a ball, B, suspended by a string rests against the end of the rod at A^1, if a sharp blow from a light

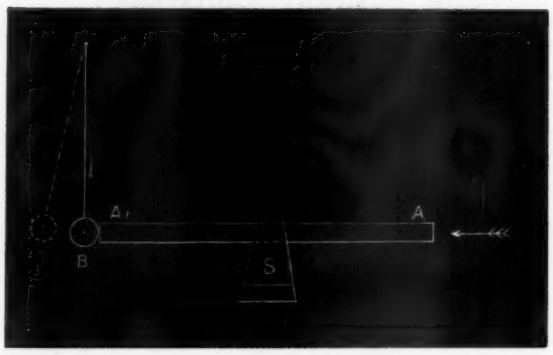


FIG. 7.

hammer be given to the rod in the direction shown by the arrow at A, the ball will be propelled as indicated by the dotted lines. A similar result may be produced by simply rubbing the rod in the neighbourhood of A, so as to throw the molecules into a state of vibration.

Now, whatever may be the cause of the appearance of electrical momentum, the preference manifested by lightning for a straight course when passing through a conductor makes it difficult to my mind to comprehend an electrical discharge leaving a longitudinal path when there is a clear road through it to the earth; but this is what Prof. Lodge seems to think does happen, and he attributes it to oscillations and the surging of electric discharges in the lightning conductor, for he says in the first of his two lectures:—"If the earth is bad, the flash can show its displeasure when it gets there by tossing it about, and boring holes into it, and breaking water and gas mains; but at least it might leave the top and middle of the chimney alone, it might wait till it got to the badly conducting place before doing the damage. Yet it is notorious that on high chimneys a flash often refuses to follow a thoroughly good conductor more than a quarter or half way down, but takes every opportunity of jumping out of it and doing damage. Why is this? Well, that is the main question I shall attempt to answer in this course."

I must differ from Prof. Lodge when he says:—"If the earth is bad the lightning can show its displeasure when it gets there by tossing it about, &c." Dessicated earth and dessicated wood are good insulators, both owe any conducting properties they may possess to moisture associated with them; this moisture is an electrolytic conductor, and the finely-divided water particles become polarised by a sudden discharge, developing, then, enormous resistance. What I have just stated I may, by the way of parenthesis, say incidentally explains the two-fold behaviour of the wood table on which the jars rest in the "alternative path experiments." Wood allows of slow conduction to electric currents of any potential, and therefore the charging of the jars was not seriously impeded, but to a sudden discharge the wood becomes practically a perfect insulator, and the discharge consequently leaps

a considerable air space in preference to passing through the wood.

We are familiar with two examples of oscillations, viz., the pendulum and the spring; in both cases matter is being acted upon by force, the oscillations being solely due to the fact that matter possesses weight and inertia. Inertia, as stated in an earlier portion of this article, I am disposed to regard as a storage of force. Weight represents the amount of inertia possessed by matter, and rate of motion, it seems to me, expresses the quantity of force stored up in the moving body; for example, four times the force must be expended to give a rifle ball twice the initial velocity of another one; two parts of this force would appear to be imparted directly as velocity, and the other two parts to be stored inside the ball, and consequently if the ball be projected vertically it resists the action of gravity for twice the time and travels through four times the space.

I have gone into this subject somewhat at length, because I wish to emphasise the fact that oscillation involves matter. I think it would hardly be too much to say all oscillations we are familiar with are a consequence of a storage of force in matter; if we assume this to be so, would it be too much to suggest that if there be such a thing as electrical oscillation, that matter must be concerned in such oscillation.

Prof. Lodge does not seem to doubt the existence of electric oscillations, and he conjectures many millions of oscillations occur in the space of a second in the case of a lightning discharge, consequently it may be considered impossible for their existence to be occularly demonstrated.

Let us, therefore, consider a Leyden arrangement whose rate of discharge is not so rapid. Take, for example, a long submarine cable statically charged to a high potential, it will be found to discharge itself in a precisely similar manner to water through a pipe inserted into the bottom of a reservoir of water where the rate of flow would be determined by the height of the column, and the diameter of the pipe and this rate of flow would decrease as the height of the column of water in the reservoir decreased, there would be no such thing as oscillation under the conditions I have described, but if the discharge pipe were a long one, and if it were elastic it would become distended by the pressure to which it was subjected, and as the pressure became less the spring of the pipe would react forcing back the water, and in this way oscillations might be set up.

Let us now consider what would occur if a charged condenser be connected through a long conductor to second condenser which is not charged, the electricity would rush out of No. 1 condenser through the conductor into No. 2 condenser; the rate of flow in the first instance being determined by the potential to which No. 1 had been charged, and such rate of flow would decrease directly as the potential became lowered by discharge. The magnetic inertia of the conductor would cause a certain amount of obstruction which would have to be overcome; in other words, energy would be stored up in the form of magnetism, and as the potential of No. 1 condenser became lowered, this stored up energy would be given out and the effect would be to continue and prolong the flow into No. 2 condenser, the potential of whose statical charge would thus become raised to a higher degree than that of No. 1 condenser. When this point has been reached a reaction would occur and the electricity would flow now from No. 2 condenser back again into No. 1. The reversal in the direction of the flow involves magnetising the conductor in the opposite direction, storing up energy again (in a less degree to that previously described) and prolonging the flow into No. 1 condenser. In some such way as just explained it is, I think, conceivable that oscillations may be set up in a conductor, and granted this be so, my contention is that any electrical oscillation which may occur must be set up by some action in the conductor itself, and the only source from which they can proceed, as far as I am able to see, is the magnetic inertia of the conductor. Now if this be the source of such oscillations, then the discharge must take place through the interior of the conductor and not pass over the outside, as Professor seems to consider to have been "abundantly" demonstrated.

I may remark, by the way, that although the existence of oscillations are taken for granted, there is no suggestion in Prof. Lodge's lectures how the oscillations are produced.

Oscillations in a lightning conductor involve the assumption that the earth acts as a condenser and not as a conductor; and assuming such oscillations do occur, they must be a consequence of the magnetic inertia of the lightning conductor, they can hardly be considered to be produced in the air space separating the clouds from the earth, for if they were developed here the oscillations would be confined to the air space, the lightning conductor and the earth, and they would not surge about through brick walls to conducting matter in the interior of protected buildings, as suggested by Prof. Lodge.

I wish to put the matter as fairly as I can. I am no partisan, but simply a student anxious to arrive at the truth whatever it may be. If there be oscillations they must have their origin in some source, and if they rebound from the earth one cannot easily conceive their surging about and reaching the earth through a different channel to that in which they occur. For my own part, regarding the earth as I do as a conductor, I cannot imagine when there exists a good connection between it and the lightning conductor, such a thing as oscillations being set up in the lightning conductor.

(*To be concluded.*)

THE NEW YORK ELECTRIC LIGHT CONVENTION.

THE Electric Light Convention is over. The meeting was the most largely attended of any ever held by the association, while the papers, discussions, and reports were of unusual interest.

Mr. Johnston, of the New York *Electrical World*, has with his usual enterprise mailed a full stenographic report of the meeting to his subscribers just a week ahead of the regular date of the paper, and with a courtesy which we fully appreciate he has sent us an advanced proof of a long, but very interesting paper, by Mr. S. S. Wheeler, on "Overhead and Underground Wires in New York," and also proof of another interesting discourse on "Some Methods of Electrical Measurements," by Dr. Liebig.

The following are abstracts of the same:—

OVERHEAD AND UNDERGROUND WIRES IN NEW YORK.

In 1884 the Legislature of the State of New York enacted a law to the effect that electrical companies in the City of New York and Brooklyn should place their conductors underground. The local authorities were expected to enforce this law, and the maintenance of electrical conductors overhead in these two cities after a certain day was declared to be unlawful.

Of course, the business of telephoning, telegraphing, and electric lighting could not be disposed of so summarily, and before the day appointed upon which the maintenance of wires overhead was to become unlawful fell due, the Legislature enacted in 1885 a law providing for the establishment and organisation of a commission, the purpose and object of which was to provide a plan by which electrical conductors in the cities of New York and Brooklyn could be placed underground without interfering with the efficiency of the electrical service. By this law of 1885 it was provided that companies could submit to the commissions established in the twin cities plans for placing their conductors underground, and should the said plans meet the approval of the commissioners, the companies submitting them could thereupon proceed to place their conductors underground according to these approved methods.

In 1885 the question of placing electrical conductors underground was very generally disputed, and no companies submitted plans to the commission within the required time. It thereupon became the duty of the Commissioners of Electrical Subways to devise a method by which electrical conductors could be placed underground, and to compel companies to carry out the work according to this method.

The result of the investigation made by the commission to ascertain by what method wires could best be placed underground in cities was that the commission had to listen to about four hundred and fifty plans, many of them having nothing to do with the work to be accomplished, and many of them utterly absurd.

The difficulty of the problem, and the reason why the experience of other places are of so little value, will be seen when it is considered that the number of wires in a given space in New York, taking the average, is very much greater than in any other centre in the world.

The ground was so filled with gas, water, and steam pipes, sewer and pneumatic despatch tubes, and their connecting boxes and man-holes, that it was impossible to find a straight course for a conduit or even a small number of ducts; and the repairs to these, which is continually going on, would make the wires specially liable to disturbance and injury.

In order to treat the subject thoroughly, the Board of Electrical Subways of the City of New York investigated all the different systems in use in other cities, in connection with the many plans which were submitted for approval to be used in New York.

In Brooklyn there are about ten miles of Dorsett conduit, and about four and a half miles of a conduit consisting of a wooden box made of creosoted boards loosely put together, with narrower ones slid into grooves on the inside to form partitions. This duct, being loose and unstable, simply affords a means of keeping cables from touching each other and keeping them in place; and as creosote will dissolve rubber it is not a good place in which to put a rubber cable.

Another plan which has seen some slight use in Philadelphia is the Johnstone system. This consists of a broad, flat, cast iron duct, made in sections, about 6 feet long, and divided horizontally into an upper and a lower half or shell, so that a section can be removed and another substituted without cutting the wires already drawn into place. The duct is divided into a number of smaller ducts, for classifying the wires, by partitions consisting of long slabs of cast iron, which are slid into place in grooves cast in the inside of the outer shell. The feature of this system is the facility which it affords of introducing an outlet from the duct exactly opposite any lamp-post or desired part of a building, by taking off the upper or lower half of a single section and putting in its place a new half-section with a hole in it at the desired point, to which a branching elbow can be bolted.

This construction has been authorised for a distributing system in New York on Broadway from Fourteenth to Thirty-Fourth Streets, for arc lighting, &c. The work is now being prepared, and the system is, therefore, of some interest.

There goes with this style of conduit a manhole formed of a bottom, a top, and variable number of rings or sleeves placed upon the other so as to build up the height of the manhole and permit of the ducts being run out at any depth to escape pipe obstructions, &c. One of these sleeves is slit up into a number of panels bolted together, any one of which can be taken off to allow the ducts to be run out on either side at any angle.

All of the other plans by which wires have been put underground, except the Dorsett and other manhole drawing in systems used in this city, which will be described later, consist of nothing but the wire with covering buried in a trench, and are of no value beyond the taking care of their own particular wire.

Prominent among such plans may be mentioned the Edison tubes. This system, which has been extremely successful for its one kind of service, consists of heavy copper rods wound with rope, and laid in wrought iron pipes filled with an insulating compound composed of Trinidad asphaltum, rosin, paraffin, and linseed oil. This compound is run into the pipe when heated to about 300 degrees Fahrenheit, under considerable pressure, while an exhaust is applied to the other end for the purpose of drawing out all air bubbles. The end of the tubes are then plugged with wood soaked in paraffin, leaving the coppers projecting.

The chief peculiarity of this system of conductors, and the feature of which is, perhaps, most familiar to all, is the means of connecting up these lengths of tubing and conductors. The rods are connected by short pieces of copper cable terminating in suitable copper sleeves, which are soldered to the ends of the rods when in position and the bow-shaped expansion joint so formed is covered with hot compound poured into a small cast-iron coupling box which is bolted on to the junction. The lines terminate at the street crossing in large cast iron boxes, like manholes, where the rods are joined by heavy copper cables to suitable connecting device near the top.

This plan is too expensive except for very heavy conductors, but serves admirably the requirements of incandescent lighting.

Tubes of the same style, but containing a large cable of small wires, have been in successful use in carrying telephone wires out from the Twenty-First Street Exchange in New York.

Another method somewhat similar is the Brooks system, which consists of wires covered with cotton and drawn through large iron pipes, which are afterwards filled with a heavy rosin oil, so as to prevent the water from entering. This oil is a good insulator.

The remaining plans are of the lower grade of mechanical construction, and consist of wires and cables of various kinds laid in troughs and covered with some protecting substance, usually tar or asphaltum.

The results of the investigations of the commission were summed up in their second report, dated June 30th, 1886, as follows:

"The principal systems of electrical subways may be divided, first, as to their material composition, and second, as to their mechanical construction, and the manner in which the wires are placed in them.

As to material composition, subways are:

1st. Of insulating material, such as wood, glass, concrete, &c.

2nd. Of conducting material, such as iron.

As to mechanical construction, subways are generally speaking:

1st. Tunnel systems.
2nd. "Drawing-in" systems.
3rd. Solid systems.
4th. "Dropping-in" systems.
5th. Combined systems.

Tunnel systems, or those where space is provided underground sufficient to allow the passage to and fro of men who place the wires within the subway, could be recommended, were unlimited time and money at the disposal of the commission; but the expense of such a system and the crying need of immediate action preclude the adoption of such a plan. If ever underground railroads become a feature of our city transportation then, perhaps, the tunnel can be used for some of the future trunk line cables.

In Paris, where the foundations of the city are honeycombed in all directions by large sewers, such a plan is practicable and admirable, but not to be thought of in New York.

Drawing-in systems, or those where man-holes are provided in the streets, connected by tubes or pipes, through which the wires can be drawn, are next in prominence and convenience to tunnel systems.

In Chicago there were seen in successful operation nearly twenty miles of conduits of the "drawing-in and out" pattern of various materials, containing all kinds of wires, as follows:

Eight miles of the Dorsett system of concrete conduit divided into ducts, and containing in the separate ducts wires of the city telephone, telegraph and fire

service, electric light wires and wires of different telegraph companies.

Four miles of the Johnstone system of iron conduit divided by metal shelves, and carrying the wires of the Postal Telegraph Company.

One mile of 3-inch iron pipes, four in number, carrying the wires of the Western Union Telegraph Company.

Three miles of iron pipes, carrying the wires of the Bankers and Merchants' Telegraph Company.

In Philadelphia a comprehensive "drawing-in" system of iron was seen, containing electric light and telephone and telegraph wires.

In Boston some two miles of such "drawing-in" iron systems are in operation.

In London 9,000 miles of wire are underground, bunched into cables and drawn into 3-inch iron pipes.

Solid systems, or those where wires are permanently embedded in insulating material and incapable of being reached except by tearing up the streets and the insulation, have been found to work with more or less success. The Commissioners saw several miles of this conduit in successful operation in Chicago by the Telephone Company there, where wires were buried in an asphalt or coal-tar cement, laid in a wooden trough.

Several miles of similar conduit are in use in Washington for electric lighting, and there are other instances of the successful operation of this description of conduit.

In this city of New York there are several systems in use underground, each more or less satisfactory to those employing it.

A prominent example is the Brooks system used by the Metropolitan Telephone and Telegraph Company. It consists of an iron tube in which cotton-wrapped wires are drawn, and the tube filled with oil, the oil acting as an insulating medium. It is kept at a desired pressure—the tubes constantly full by means of a standpipe. They use a 2½ inch iron pipe, and the system is cheap, costing less than $11 per mile of wire, because into such a pipe they can draw 300 telephone wires. Wires for telephone purposes, and those used in the American District and other call boxes, are of a very light intensity, and do not need as heavy insulation as do all other kinds. This system is claimed to give perfect satisfaction for telephone conductors.

The Western Union Telegraph Company has many wires already down in this city, laid in 3 inch iron pipes, into which they draw cables manufactured from okonite or kerite insulation. These pipes are lead-jointed, are laid in Broadway, and have man-holes occasionally for taking out the wire.

To sum up as to the form of subway, and the manner in which the wires are to be placed in it.

We are convinced that from the standpoint of an electrician simply it may be said that almost any plan or system can be made to work from a single lead covered wire laid directly in the earth to a great tunnel upon whose walls the insulated conductors can be hung. Within certain broad limits any system is electrically practicable; retardation and induction can be over come. It is only when we face in this city the mechanical engineering and chemical questions of interference with water pipes, gas pipes, and sewer pipes, of obstructions from vaults, or danger from steam pipes, of the action of sewer and illuminating gas, that the necessity for careful discrimination presents itself.

The commission give their approval to a "drawing-in" system with frequent man-holes as the general form of subway best adapted to meet the requirements of the electrical service of the present.

After a thorough investigation and discussion of all the different materials, and the advantages and disadvantages of each, it was finally concluded that a conduit or subway for electrical conductors under ground is merely a mechanical protection for the wires to be placed therein, and should afford the very best protection possible to be procured, while the electrical protection or insulation may be safely left to the manufacturers of cables and wires to be placed in subways.

It was decided that the use of metallic tubes would not seriously interfere, by induction, with the working of the wires, and were to be preferred because the continuous conducting shield so formed will carry off any escaping current and prevent damage to other cables. Accordingly conduits of iron gas pipe embedded in concrete were put down, and these seem to be about the best kind so far constructed. They are best, first, because there are plenty of workmen who understand gas pipe fitting and laying concrete, and because they are durable and entirely non-combustible. The purpose of the cement is to prevent the iron from rusting, which it does very effectually. If in time the pipes are destroyed by rusting from the inside, the solid hydraulic cement concrete will remain, furnishing a permanent duct with a hard, smooth bore.

The manholes used in connection with these various kinds of ducts have nearly all been built of brick laid in hydraulic cement, and capped with an iron casting to form a seat for the water-tight lid. The lids are usually bolted down upon a rubber gasket, but unlike the Edison manholes, instead of being held by a single thrusting screw which passes through a crossbar, presses down upon the centre of the cover. Some of the lids have been made funnel shaped so as to cause water to drain away from the edge and collect in the centre. By this means the liability to leakage at the gasket is diminished, because there is less chance of water standing over the joint. The facility of opening the manholes afforded by this method of fastening the lid with a single screw is of great value in reducing the labour and time required to open and close a line of conduit when laying a wire, and is a material advance in the solution of the problem.

In regard to moisture in the conduits. In the iron tube plan, which is the best, there is, of course, no leakage, because the tubes themselves are water-tight, could even be made air-tight, and because they are covered with cement, which is in itself water-tight. The manholes are made of watertight materials and there should be no leakage under the lid. Lookers-on find that a great many of the manholes have a great deal of water standing in them; this is simply because the lids are not fastened down, but simply laid in place by the builders, often without any gasket, and the manholes fill with rain and stay full until cleaned out for use. When cleaned and closed properly they appear not to receive any water by leakage.

There is, however, another source of moisture which is hard to overcome, the condensation of vapour from the air which the manhole and ducts contain. Every time a hole is opened it refills itself with warm air, containing more moisture than it can keep when cooled down to the temperature of the masonry; consequently as soon as the lid is screwed down this fresh air deposits a dew on the inside of the manhole. As it is impossible to open and dry out a manhole without putting in new air, which will condense in turn, no amount of cleaning will overcome this difficulty. The presence of moisture tends to corrode exposed wires, and therefore the question of whether it is better to protect the splices and make the insulation of the wires so that they will not be injured by this moisture, or to dry out the entire system of conduits by a system of ventilation, is unsettled. But this question, fortunately, is one of minor importance.

The question of distribution of electrical currents from the main subways constructed in the manner described has been largely left by the authorities in the city of New York to the preference of the electrical companies.

Two systems of distribution are at present actually in use in New York by the telephone company. These are known as the house-top system of distribution, an example of which may be seen at Sixth Avenue and Fifty-First Street, and the hand-hole system of distribution, which may be seen at Broadway and Exchange Place.

In addition to these systems, there are five modes of distribution which can be readily applied to the subways as constructed in New York, and which will be allowed in cases where they are severally most expedient, the lamp-post system of distribution, the house-

front system, the house-vault system, now in use in Chicago, the backyard system, and the manhole system. In the heart of Chicago the distribution question is peculiarly easy of solution, because the side-walks were left hollow by raising the street levels after the great fire, and the wires are run through these spaces to the houses.

Having decided the question of the kind of conduit to use, the commission proceeded to have subways constructed according to these plans. It was decided best, as a matter of expediency and to prevent accident, that electric light subways should be distinct from those intended for telephone and telegraph service, and it has, therefore, been the practice of the authorities in New York to build subways for one class of conductors upon one side of the street, and reserve the other side for those of other service.

The telephone people were the first to realise that underground wires were sure to be ultimately a success. They came forward, and were the first to declare for underground wires.

After some resistance, the telegraph and electric light companies have come to the conclusion that it is as well for them to comply with the demands of the public and place the bulk of their conductors underground. And, as a matter of fact, in the city of New York to-day there is but one single company out of the large number doing business here which refuses absolutely to comply with the provisions of the subway acts, and nine-tenths of the opposition and outcry has been caused by this company.

At the present time the total construction of single duct in the city of New York amounts to 420 miles. In these subways there are already in operation some 4,000 miles of telephone and telegraph wires, and some hundreds of miles of incandescent electric light conductors. Cables for arc lighting are to be drawn in on Broadway from Fourteenth to Thirty-Fourth Streets by the Brush Electric Illuminating Company within the present week.

There are already underground in the city of New York more electrical conductors than in any other city in the world, while the capacity of the construction already finished in this city may be estimated fairly at something over 30,000 miles of conductors.

The Board of Electrical Control is not unmindful, however, of the magnitude of the labour and expense required in converting the present arrangements into underground systems, and does not contemplate either the hampering of the business of electrical companies by forcing unreasonable numbers of wires underground, or by attempting to compel the use of subways faster than is consistent with the efficient use of the different electric service by the public. If the great mass of overhead conductors are removed, and the remainder of the service brought to a condition which will insure the safety of the public and, at the same time, the welfare of the companies themselves, it will be the result desired by the people of the city, and which the Board of Electrical Control is endeavouring to attain.

In conclusion, the situation may be summed up about as follows. The telegraph and telephone problem is practically solved. It is found necessary to resort to subways in order to get sufficient space for wires, and wires for this use are being drawn into the tubes as fast as the labour can be performed. There are about 4,000 miles of telephone and telegraph wire already underground, and 12,000 miles of cables about to be laid in the fall. It is estimated that the saving in cost of maintenance will be about $100,000 per year, owing to the permanence of the style of work which is possible underground.

The laying of electric light wires has not been so fully developed, and naturally none of the companies care to bear the expense of the first experiment. But after the initiative has been taken, the difficulties will be overcome as they arise, as in the development of all other enterprises, and the undergrounding will become a settled and accepted fact.

Meanwhile the lawless running of overhead wires is being stopped. All wires in a street must be run on a single line of poles. Here and elsewhere the dead wires and poles must not be stored in the streets, and all construction must be made under the supervision and control of some official in precisely the same way that other works which affect the public are carried on.

SOME METHODS OF ELECTRICAL MEASUREMENT.

Current determinations may very conveniently be divided into two groups, *i.e.*, the measurement of heavy currents and the measurement of small currents. Of the latter very little need be said, as the best method undoubtedly depends upon the use of an electro-dynamometer, and the most suitable form of such an instrument is that of the British Association, the well-known Weber electro-dynamometer, which has been thoroughly explained and mathematically treated at length by Maxwell. With two or more electro-dynamometers of this kind, currents, ranging from a few milliampères to 10 or 25 ampères, can readily be measured with an accuracy of one part in two or three thousand. Currents greater than this must be determined by some other arrangement, since a dynamometer capable of accurately measuring very heavy currents would have to be of massive proportions and of correspondingly increased cost. An instrument at the Johns Hopkins University, which is intended to measure currents up to 15 ampères, has fixed coils one meter in diameter.

For heavy currents it has been found advisable to apply the method of "fixed resistances," a method which has been used and successively improved in several electrical exhibitions in this country and abroad, and the range of which is practically unlimited. In this method the current to be measured traverses several heavy German silver bars which have been hard soldered to a pair of very large copper blocks to which are fastened in the same way the terminals of the galvanometer leads. The bars and end blocks are immersed in a tank of refined petroleum, and their temperature, by stirring constantly the oil, can be determined to a few hundredths of a degree. To use this apparatus a known current, measured by an electro-dynamometer, is sent through the fixed resistance, and the potential at the ends determined by the galvanometer joined at these points. The deflection of the latter corresponding to any other current, gives us at once a measure of the current. In practice, a resistance-box is placed in circuit with the potential galvanometer, and the resistances are always adjusted until approximately the same deflection is obtained. By doing this we render ourselves independent of the assumption that the angular deviation of the galvanometer needle is proportional to the current, except for exceedingly small differences. It is to be noticed, however, that the calibrating current is measured by an electro-dynamometer, and not by a galvanometer, the reason being, that the former is independent of the value of H (the earth's horizontal component), whereas any error in the determination of H appears directly in the galvanometer constant.

During the measurements the oil in the tank is constantly stirred and its temperature noted. As a matter of fact this is found to change but little even with currents of 200 ampères or more. Calling R_0 the resistance of the German silver bars at 0° C; β their temperature coefficient; T_1 and T_2 temperatures of the same corresponding to currents C_1 and C_2; D_1 and D_2, r_1 and r_2, t_1 and t_2, the deflections of galvanometer, adjusted resistances, and their temperatures, respectively, corresponding to currents C_1 and C_2 we have

$$C_2 = C_1 \frac{D_2 (1 + \alpha t_2)\, r_2 \,.\, R_0 (1 + \beta T_1)}{D_1 (1 + \alpha t_1)\, r_1 \,.\, R_0 (1 + \beta T_2)};$$

α being the temperature coefficient of the resistance box. The terms relating to changes of the resistance, R_0, *i.e.*, of the German silver bars, can generally be neglected.

Potential measurements can be made in exactly the same general manner, the "fixed resistance" used for this purpose being, however, very much higher. A known current is passed through the German silver reel, forming the fixed resistance, and the deflection of the galvanometer, joined to its ends, is noted. A resistance box in circuit with the galvanometer enables us to reduce this deflection to a convenient angle. Care must be taken that the current used for calibrating the galvanometer be so small as to heat the fixed resistance as little as possible. After the calibration is completed the galvanometer is joined to points whose electromotive force we wish to measure, and the resistance box adjusted until the same deflection as before is secured. We have then an expression for the potential, of exactly the same form as the one given before. For very high potentials the method is inapplicable, and recourse must be had to an absolute electrometer of the kind first described by Sir William Thomson. In this instrument, fully explained in Thomson's papers, the difference of potential between two points is measured by the attraction between two discs electrified to the same difference of potential, one of them being balanced by a series of weights, the other being fixed. With such an instrument electromotive forces varying from 1,000 volts to over 100,000 volts can easily be measured, and it thus offers an excellent means of comparison with electrostatic voltmeters, &c.

There is, perhaps, no better way of measuring resistances than by the employment of some accurate and sensitive form of Wheatstone bridge. The only difficulty encountered in such measurements is the exact determination of the temperature of the various resistance coils and standards in use during the work. It has been found absolutely necessary to immerse all the measuring coils in liquid during the use of the apparatus, and to allow them to remain in a room whose temperature is almost constant several hours before any measurements are made. Even thin glass tubes containing mercury and surrounded on all sides with cracked ice have been found to require at least five or six hours for their temperature to fall to zero.

The efficiency of dynamos and motors can be determined with all necessary accuracy by means of any one of several dynamometers of distinct types, and now well known, and the subject is one which presents no difficulty whatever, until the attempt is made to measure the efficiency of very small machines; that is, machines of one horse-power and less. In these cases it has become necessary to devise a way of measuring which shall greatly reduce errors ordinarily encountered. The difficulty generally presented is that the dynamometer itself absorbs in friction so much energy that the loss thus occasioned amounts to a large proportion of the total activity of the machine under examination. The cradle dynamometer is, perhaps, free from this objection, but it must be rejected on account of the uncertain but large errors introduced by slight errors of centering. Hopkinson's method might be employed, were it not that it requires two machines to experiment upon; an obstacle which in most cases would be a serious one. A method which appears to be devoid of the objections just enumerated is a modified calorimetric method. To employ this the motor or dynamo, as the case may be, is surrounded by an air-tight water jacket, through which circulates a stream of water at a uniform temperature. The dynamo is allowed to run under a given load until all the effects of heating have become constant; this includes the heating resulting from mechanical friction, and from the current itself. After this the flow of water is determined, its temperature carefully noted, and from these data the losses occurring in the motor are at once deducible. There appears to be nothing in the way of making the method universally applicable to small machines, and the indications are that its adoption would lead to very accurate results. This method was first proposed by Dr. Duncan, as a means of measuring the efficiency of alternating current converters.

Several methods of determining the magnetic qualities of iron and steel have been published. They all depend upon the measurement by a ballistic galvanometer of the induction through a coil wound about the specimen to be tested, either when the coil is moved, the current reversed, or reduced to zero. These methods offer no difficulty, and a ballistic galvanometer can easily be calibrated in absolute measure by the use of an earth inductor, or even a coil of wire of a few turns, its constants having been determined by measurement and simple calculation.

CITY NOTES, REPORTS, MEETINGS, &c.

Victorian Electric Company, Limited.

THE ordinary general half-yearly meeting of the shareholders in the Victorian Electric Company was held on July 31st at the City Bank Chambers, Melbourne. Professor Kernot occupied the chair. There was not a large attendance.

The Chairman, in moving the adoption of the report, remarked that there was renewed public interest in the system of electric lighting, and its position was much better than at the time of their last half-yearly meeting. As to the primary battery, which would give the electric light to individual houses, and which it had been thought would injure this company, he said he had looked into the matter, and found that while it might be a good thing in some cases of out of the way buildings, where people were willing to pay a high price for it, there was no more possibility of its competing with electric lighting by dynamo than that kerosene could compete with gas. The proposal to lay the wires underground was about 25 years old, and had been used for telegraphs for that period, but results did not justify its extension, and no scheme had ever answered the purpose from an all round point of view. This company had given it an extended trial in Bourke Street, but gave it up because it was generally inferior to the overhead system. The cost of the Exhibition installation, said to be over £60,000, was chiefly incurred in the machinery, and should be taken in comparison, not with a gas supply from already existing works, but with the erection of new gas works, which would probably not supply anything like the same light for the same price. Besides this, the plant and machinery would finally go over to the railway department for use at the various stations, and would have the added value of a thorough test.

Mr. F. A. Walsh asked for an explanation of the difference in the valuation of the assets and goodwill now stated in the balance sheet, as against those of the November statement.

Mr. F. C. Rowan, the managing director, replied that the values now stated were the values recommended by a committee appointed by the shareholders themselves in November, and were adopted in accordance with that instruction.

The report was adopted.

A special general meeting was then held to consider the voluntary liquidation of the company for the purpose of extending its operations by the formation of a new concern.

Mr. Rowan moved that the company be wound up voluntarily. He said that this motion had the full consent of the shareholders in London, who had authorised him to act under the altered conditions, and thus the patent rights would be secured to the new company. Negotiations with another company were still going on, and it was hoped that they would be of distinct value to this company.

Mr. H. Fink seconded the motion, which was carried.

The following consequent resolution was agreed to:—

"That Mr. J. F. Levien, Mr. F. C. Rowan, and Mr. H. Fink be appointed liquidators to sell and transfer the business, property, and goodwill of this company forthwith, or at any time hereafter, to a company registered under the Companies Statute, 1864, for the purpose of purchasing the same, and to receive in compensation for such transfer or sale shares in such new company, for the purpose of distribution amongst members of this company; or, if thought expedient, authorising the liquidator or liquidators to enter into any other arrangement whereby the members of this company may, in lieu of receiving cash, shares, or other like interests, or in addition thereto, to participate in the profits of or receive any other benefit from the purchasing company."

The meeting then terminated.

TRAFFIC RECEIPTS.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending September 7th, 1888, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, were £4,011.

The Brazilian Submarine Telegraph Company, Limited. The traffic receipts for the week ending September 7th amounted to £4,963.

ABSTRACTS OF PUBLISHED SPECIFICATIONS, 1888

137. "Improvements in apparatus for producing induced electric currents." J. C. PUETHNER. Dated January 4. 8d. Relates to modifications of the apparatus described in letters patent No. 9,706, dated August 14th, 1885. The claims are 14 in number.

1851. "Improvements in graphophones or instruments for recording and reproducing speech or other sounds." J. Y. JOHNSON. Dated February 7. 1s. 3d. Comprises certain improvements upon the apparatus described in the specification to letters patent No. 6,027, dated May 4th, 1886, and upon instruments of the same type. The claims are 25 in number.

1932. "Improved forms of electrical contacts for switches and similar fittings." F. H. ROYCE. Dated February 9. 6d. Consists of improved forms of electrical contacts for switches and similar fittings in which the two parts which make or break contact are fitted each with a pliable and removable strip or strips of metal which slide one on the other. And a contact made of a strip or strips of metal bent into the form of a V or similar form, either with two, one entering the other: or one fitting round or in the opposite contact. The claims are 2 in number.

2246. "Improvements relating to dynamo-electric machines." H. H. LAKE. (Communicated from abroad by R. Eickemeyer, of America.) Dated February 14. 1s. 1d. One object of this invention is to reduce the crossing of wire in each coil, at the ends of the armatures to a minimum, and to avoid close contacts, wherever the path of any portion of the wire is angular to the path of any other portion, whether the said portions of wire be in one coil or in several coils. Another object of this invention is to enable all of the conductor coils or windings to be readily removed from the armature, and to keep each practically intact for ready replacement thereon, and thus to provide not only for the substitution of a new coil for an imperfect one, but also to economise wire and reduce the cost of applying coils to armatures. The claims are 8 in number.

3075. "An improved clutch for regulating feeding rods in electric arc lamps." A. W. SOUTHEY. Dated February 29. 6d. Consists in constructing a clutch of two pieces of metal plate hinged together, having a bevel hole in the centre so as to allow the feeding rod to pass through it. The claims are 2 in number.

CORRESPONDENCE.

Galvanic Belt Quackery.

I shall not allow the person who writes in your paper as "J. Jerritt, A.S.T.E. & E.," to vilify me or to make unfair, incorrect and malicious statements regarding me. I did not obtain an "electropathic" belt for Mr. Carpenter's examination, and I repeat that on no occasion have I ever recommended the belt in question. Let Mr. Jerritt produce the proofs of his assertion. Mr. Jerritt would make an excellent Old Bailey lawyer. He excels in twisting his, or rather my, case. Nevertheless, I shall keep his nose well to the grindstone of fact. Mr. Carpenter examined for me a medical battery belt, and warranted it genuine as made by Mr. Harness some years ago. There my connection with Mr. Harness's belt ended. Perhaps Mr. Jerritt cannot understand this "plain English." If not, his is the misfortune. I fail to see what the Ammoniaphone has to do with electrical belts at all. I became convinced the latter appliance was a good method of applying medicated substances to the larynx and lungs. Hence my approval thereof. If Mr. Jerritt hereafter attempts to foist any approval of bogus belts on me simply because I approve of the Ammoniaphone, he will richly deserve, in addition to the complex alphabetical designations at present appended to his name, to have added other significant letters.

Andrew Wilson.

Health Office, *September 5th*, 1888.

Lightning.

Prof. Oliver Lodge, in his letter to your Journal, says:—"When the stage is so high and the spectacle so extensive, a back seat is preferable to one too close in the front for obtaining a comprehensive view!" I quite agree with him, for the words quoted from his letter support one of my main contentions, and they seem to me to simply reiterate that portion of my article where I say:—"To make important progress it is necessary to leave the beaten track travelled over again and again by the scientific schools, and to seek some elevated standpoint from the outside where we can look down upon matter and its associated forces as a whole."

Prof. Lodge acknowledges the newer theory which he has lately been elucidating to be "*singularly complex*," and far less simple than the older hydraulic view of electrical transmission, and he confesses he himself would prefer the hydraulic view "if it were the true one."

I take it, nevertheless, Prof. Lodge would wish us to believe he has convinced himself of the truth of the more complex theory, for he refers to it as the "real manner of transmission," and expresses a wish that he was the discoverer of it.

The matter at issue is very fairly put where Prof. Lodge says: "It is no question of flights of fancy; it is a question of downright fact." I cannot, however, agree with him when he suggests that one of the two theories must be the correct one. I would rather put it: one of these two theories is probably truer than the other."

Truth, I am disposed to believe, is more often found in the company of simplicity than in that of complexity. The older electrical theory is the outcome of experiment; it has proved useful in the past, and it harmonises with what is observed when energy is transmitted either hydraulically or mechanically. Now, as far as I know, the newer theory has no experimental support, but is a purely hypothetical superstructure, resting on hypothesis for its basis.

If we read the history of the past, I think we can scarcely fail to observe that Nature has revealed herself in a greater degree to those who have worshipped her in her simplicity. Men like Franklin and Faraday in the past, and, I should like to add, Prof. Hughes in the present, have accomplished most of their work with the simplest of apparatus; this, to my mind, is the test of the true philosopher, and men such as I have mentioned are only exceptionally the outcome of scientific schools.

I am aware that in the eyes of some I commit the unpardonable sin when I confess I set very little value on the speculations of even our admittedly greatest scientific men unless they be supported by experiment.

Were I to worship "scientific giants" I should probably believe (like some of them do) in spirit-rapping, which I now look upon as a species of madness, more often to be found associated with great mental activity than with duller mental capacity.

I acknowledge to being an enthusiast, and I claim the right to think for myself, but I am a partisan of no theory. I agree generally with the spirit of that expressed in the last sentence of Professor Lodge's letter, viz:—that if a theory does not accord "in every particular with fact, by all means let it be overthrown," but I should be inclined to say, It passes the wit of man to propound a theory which does accord in every particular with fact, and I hold this ought at all times to be recognised, and never for a moment forgotten by the scientific student, who should regard theories as more or less useful tools, and not accept them as articles of faith.

Electrical science has been laid under an obligation to Professor Lodge more than once. He has now fairly challenged the older school of thought. Whatever may be the issue, science can scarcely fail to be the gainer, and, therefore, all who have at heart the advancement of science, should feel indebted to Professor Lodge for the elucidation of the newer theory, and for the discussion he has set going.

I observe a contemporary charges me with being "decidedly dogmatic." Of course, I cannot express an opinion on this point, but it may be permitted me to give utterance to a hope that your readers, as a whole, will not have come to a similar conclusion.

S. Alfred Varley.